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Report Number: KP-570, Part No. 17

UNION CARBIDE NUCLEAR COMPANY

Production Division

Utility Operations Department

SUMMARY OF RECIRCULATING WATER TREATMENT TESTS FOR MARCH THROUGH JUNE, 1956

C. C. Fowlkes

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TO Mr. H. G. P. Snyder
LOCATION K-303-8

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DATE August 28, 1956

ANSWERING LETTER DATE

SUBJECT Summary of Recirculating Water Treatment Tests for March through June, 1956

KP-570, Part No. 17

In addition to discussions of operating results of all recirculating water systems, this report contains the usual "long-term" corrosion curves and "short-term" corrosion curves for the K-31 and K-33 recirculating water systems.

Freon Condenser Corrosion

After about eight months of operation, a large amount of information has been obtained and compiled by the Engineering Development and Metallurgy Departments. From their interim reports, the following points appear to be most significant:

1) The K-31 return test condenser at 152° F is showing very definite pitting while the K-33 return at 140° F shows no pits.[1,2] These return test condensers do not have a heat load on them and are comparable to the Utilities Department copper test nipples. Results obtained on the K-31 test condensers are further discussed under "E Loop (K-31)" test and operating results.

2) There is a slight localized attack on the K-33 supply condenser tubes (104° to 155° F) and none in the K-31 supply (85° to 140° F).[3,4,5] Apparently the heat load aids the Calgon-Coraid treatment as used in K-31 to lay down a protective film.

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[1] Technical Division Weekly Report for the Week Ending May 25, 1956, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, May 28, 1956, (KLI-3525-48). (Secret)

[2] Technical Division Weekly Report for the Week Ending June 8, 1956, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, June 11, 1956, (KLI-3525-50). (Secret)

[3] (KLI-3525-48), op. cit. (Secret)

[4] (KLI-3525-50), op. cit. (Secret)

[5] Technical Division Weekly Report for the Week Ending June 29, 1956, (KLI-3800, Part 1). (Secret)

3) Twenty selected tubes were removed from K-33 condenser K-902-4.2 odd (ERD # 638). This unit had been out of service three times previously for plugging and is now to be shipped out for retubing. The twenty tubes were so selected as to represent some plugged during each of the three outages in addition to randomly selected open tubes.

   Examination by Metallurgy[6] revealed that tuberculation and pitting was generally more severe in tubes from the first and second passes than tubes from the third and fourth passes by a numerical factor of three. The bottom halves of all tubes are generally more severely attacked than the top halves by a factor of four. No significant difference was found in the amount and severity of tuberculation and pitting in the open tubes compared to those plugged--which seems to indicate that improved water treatment at K-33 is having a beneficial effect on reducing the rate of attack.

4) The K-801-A test condenser was started on simulated Nalco treatment on May 28. On June 15, the test system was inadvertently drained, and three tubes were removed at this time. In this period of time no pits had developed, and only 10 to 20 per cent of tube surface showed light etching. The test loop was restarted on June 22, and present plans are to discontinue the Nalco trial on July 22 so that a test run may be made on unchlorinated Poplar Creek water.

Tests and operating results of the individual loops are as follows:

A Loop (K-25 East)

During this report period, the "A" loop supply temperature was slowly increased from 80° to 95° F. Apparently the increased velocity resulted in some cleaning of the coolers, as the average water control valve positions as measured in K-309-2 changed from 55 to 45 per cent open. There was, however, a total flow increase from 48 to 52 million gallons per day, which is much less than would be expected for a fifteen-degree rise in supply temperature. The main purpose for the increase in "A" loop supply temperature is to equal that of "B" loop so that the two systems may be tied together for greater operational safety and flexibility.

B Loop (K-25 West)

There were no significant changes in heat transfer characteristics, as both the total loop pumpage and the water control valve positions as

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[6] Technical Division Weekly Report forthe Week Ending June 22, 1956, (KLI-3525-52). (Secret)

measured in K-304-4 showed little change.

C Loop (K-27/K-29)

In May the control point for the "C" loop supply temperature was raised from 80° to 85° F to obtain higher water velocities. During the report period the pumpage requirements increased from 49 to 56 million gallons per day. This increase was apparently fairly evenly divided between K-27 and K-29, as the water control valves in K-402-3 changed from 56 to 62 per cent open, and the control valves in K-502-1 changed from 26.5 to 30 per cent open.

In May a K-29 freon condenser (K-502-3.8) was removed from service because of freon leakage. Examination of two tubes revealed severs pitting. This was the first evidence of severe pitting of K-29 condensers, and immediate changes were made in an attempt to obtain more copper protection. The Calgon-Coraid treatment, as used on "E" loop, was started June 2, with the Coraid feed rate of 5 ppm every morning and an additional 2 ppm twelve hours later. As at K-31, the feed rates are based on loop volumes--not related to pumpage, make-up or blowdown.

The badly pitted condenser which was originally installed in K-502-3.10 was removed April 26, 1955, and modified (tube sheet resoldered, etc.). This condenser was then reinstalled in the K- 502-3.8 position and was the first modified condenser to be examined after additional service. Metallurgy advanced the theory[7] that the cleaning treatment during the first outage may have initiated the pitting--case history of cleaning operation is not positive, but it is believed that the condenser had a trichloroethylene dip both before and after an alkaline dip treatment.

Metallurgy's hypothesis was apparently substantiated when another condenser from K-29 (K-502-2.10) that had not been "modified" or cleaned was examined. Four tubes from this condenser were thoroughly examined and revealed only minor pits.[8]

Test condenser ERD 6D3-403 was reinstalled on the K-29 supply on June 4 with nine new tubes to monitor this change in "C" loop water treatment.

After reviewing the information obtained from examination of the second condenser that had not been "modified," it would seem that the change in water treatment was unjustified; but now that the poor condition of all "modified" condensers has apparently been revealed, superior treatment is certainly needed to delay the expected additional failures. Betz dianodic treatment would have been used but for the associated chromate

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[7] Technical Division Weekly Report for the Week Ending June 1, 1956, (KLI-3525-49). (Secret)

[8] (KLI-3525-50), op. cit. (Secret)

problem with blowdown, nonreturn usage, and firewater pumpage from K-832.

Actually all our operating experience at K-25 indicates that there is no need for specific copper protection when operating at a pH of above 6.5. However, after starting corrosion by one means or another, it may not be advisable to return to treatments that would otherwise be acceptable.

E Loop (K-31)

The "E" loop supply temperature was slowly raised from 86° to 95° F during this report period for the purpose of increasing water velocities and cleaning the condensers. The results have been very gratifying, as this appreciable change in supply temperature was accompanied only by an increase in pumpage requirements of five million gallons per day (7 per cent).

The Utilities Department's copper corrosion test nipples, which were removed after 179 days' service on April 10, showed serious pitting, particularly on the return water. Calgon representatives were immediately contacted, and it was their recommendation that the "E" loop Coraid feed requirements be increased to the 7 ppm daily feed rate, added as previously described under "C Loop" of this report. This increase was made on May 14, and additional corrosion test nipples were installed to check this change in water treatment.

To date the effectiveness of the Calgon-Coraid treatment has been difficult to analyze. The Utilities test nipples, with no heat transfer and the return water test condensers with no heat transfer, show pits at the "low" Coraid feed rates. However, the supply test condenser, with a heat load comparable to the Cascade condensers, shows no pits. It may be that Calgon-Coraid will give excellent results where actually needed. To check the effectiveness of this treatment, a K-31 process condenser will be removed soon for evaluation of condition as compared to known condition in July 1955.

To prevent neglect of steel corrosion in our present concentration on copper, a specimen from the K-31 system (also K-33 as later described) was submitted to Metallurgy. This specimen was a section of 4" steel pipe from the return line of the P & E station. This line had been in continuous service for the last 3½ years. Metallurgy's report[9] indicates no severe pitting and a maximum of 8 per cent loss of its nominal wall thickness due to corrosion. This report is reassuring, as the service time covers all of 1953, during which four "acid cleanings" took place. All previously submitted specimens from K-31 to Metallurgy were cast

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[9]Letter from C. R. Barlow and W. W. Latham, Metallurgy Department, Technical Division, to C. C. Fowlkes entitled "K-31 and K-33 Water Lines," dated May 11, 1956, (KLI-3771).

iron elbows which, while showing no appreciable corrosion, probably were not representative of the steel piping.

G Loop (K-33)

Considerable improvement was made in heat transfer during this report period as would be indicated by pumpage requirements and return water temperatures. Pumpages decreased from 240 to 219 million gallons per day, and the return water temperature increased from 146° to 152° F. Improvement is believed to be due primarily to lower loop concentration ratios and reduced Orocol feed rates. Paradoxically, this improvement is not reflected in the water control valves as measured in K-902-4, where an increased opening from 57 to 65 per cent was recorded.

The Betz dianodic treatment is apparently doing a very good job, as there have been only six condenser failures during this report period, and all test condenser and test nipple information is encouraging.

A disk was cut from the K-33 supply header, north side, representing 1½ service years and was submitted to the Metallurgy Department for examination. Their report[10] shows only negligible attack.

Monthly Average Water Analyses

Attached are separate monthly average water analyses sheets for each month covered by this report. Some points of interest are as follows:

1. After March, the "E" loop consistently had the highest dissolved solids concentration. These relatively high concentrations were obtained although all available K-801-A make-up water was utilized. If necessary to lower the concentration ratio, make-up water from K-891 will have to be used.

2. The Coraid feed rate for "E" loop was increased on May 14, and this increase is reflected in increased cost for May and June. Where the Betz dianodic treatment previously cost about 2½ times as much as Calgon-Coraid, the June result shows a comparative cost of only about 40 per cent more on a B.T.U. basis.

3. The "C" loop water treatment was changed to Calgon-Coraid on June 1. The Coraid is being fed at the same relatively "high" rate as is being used on "E" loop; as a result, the "C" loop treatment costs increased for June. It has been previously mentioned that Calgon-Coraid treatment was less expensive than Calgon Composition T treatment, but this is true only at the lower Coraid feed rates previously used.

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[10] Ibid.

4) The dissolved copper concentrations for all loops were consistently lower than 0.05 ppm.

5) As previously, only "C" and "E" recirculating water loops, with lower chlorine additions, show any significant amounts of manganese.

Graphs of Steel and Copper Corrosion Rates

Attached are four steel and three copper "long-term" corrosion test curves. These curves, now representing close to two continuous service years, are self-explanatory and, in general, satisfactory. The "G" loop copper supply, which previously was high, continues to drop with the use of the Betz dianodic treatment.

Also attached are two "short-term" corrosion test curves for "E" and "G" loops. These curves, one for copper and the other for steel, show the corrosion rates for the K-31 and K-33 recirculating water systems after changing to Calgon-Coraid and Betz dianodic, respectively. All of these rates are at present considered to be satisfactory.

C. C. Fowlkes
C. C. Fowlkes

Approved: K. M. Jones
K. M. Jones
Process Utilities Department

MONTHLY AVERAGE WATER ANALYSES - MARCH, 1956

P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP 'A'	'B'	'C'	'E'	'G'
Total Dissolved Solids	79	108	95	254	280	316	339	358
Meta-Phosphate as $NaPO_3$	0	0	0	6.55	7.97	7.72	8.24	5.44
Ortho-Phosphate as $NaPO_3$	0.09	0.09	0.03	7.68	8.03	6.05	8.81	12.35
Total Hardness as $CaCO_3$	68	71	74	133	140	159	168	180
Calcium as $CaCO_3$	46	51	53	91	87	111	110	108
M-Alkalinity as $CaCO_3$	52	42	44	14	13	12	8	16
Turbidity as SiO_2	40.6	12.2	4.9	20.9	20.7	28.5	21.2	57.8
Copper as Cu	0	0	0	0.04	0.04	0.04	0.04	0.04
Total Iron as Fe	1.63	2.06	0.85	1.59	1.51	1.98	1.93	3.58
Chromates as CrO_4	-	-	-	-	-	-	-	21.74
Sulphate as (SO_4)	21	39	22	100	95	151	172	156
Suspended Solids	6.8	4.1	5.6	11.8	11.8	19.3	12.2	22.2
Manganese as Mn	0.05	0.07	0.04	0	0	0.21	0.34	0
Zinc as Zn	-	-	-	-	-	-	0.90	-
pH	7.51	7.28	6.80	6.79	6.80	6.56	6.09	6.00
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon, Comp. T	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.697		$1.308	$1.483	$2.437
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	3.07		3.73	3.19	6.96

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - APRIL, 1956

P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP 'A'	'B'	'C'	'E'	'G'
Total Dissolved Solids	112	135	119	252	265	312	378	353
Meta-Phosphate as $NaPO_3$	0	0.03	0	5.79	5.83	6.56	7.19	5.23
Ortho-Phosphate as $NaPO_3$	0.11	0.11	0.09	7.27	7.72	5.23	9.17	11.98
Total Hardness as $CaCO_3$	75	76	75	141	146	154	180	174
Calcium as $CaCO_3$	51	53	53	88	91	110	118	98
M-Alkalinity as $CaCO_3$	47	48	41	16	16	14	10	16
Turbidity as SiO_2	58.8	11.9	5.2	25.9	26.2	29.3	27.1	27.4
Copper as Cu.	0	0	0	0.04	0.04	0.05	0.04	0.04
Total Iron as Fe	1.20	1.18	0.84	1.92	1.92	1.86	1.42	3.27
Chromates as CrO_4	-	-	-	-	-	-	-	19.78
Sulphate as (SO_4)	14	19	20	74	82	99	124	114
Suspended Solids	77.4	8.0	0.4	15.2	16.6	18.0	16.2	18.3
Manganese as Mn	0.04	0.04	0.04	0	0	0.18	0.30	0.02
Zinc as Zn	-	-	-	-	-	-	1.00	-
pH	7.38	7.23	6.63	6.78	6.78	6.56	6.10	6.01
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon, Comp. T	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.562		$1.217	$1.323	$2.577
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	2.57		3.54	3.02	7.05

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - MAY, 1956

P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP 'A'	'B'	'C'	'E'	'G'
Total Dissolved Solids	158	151	196	319	322	442	590	530
Meta-Phosphate as $NaPO_3$	0	0	0	4.45	4.63	6.38	7.15	4.94
Ortho-Phosphate as $NaPO_3$	0.44	0.36	0.20	6.43	6.86	5.81	10.63	12.97
Total Hardness as $CaCO_3$	74	107	103	171	183	215	302	262
Calcium as $CaCO_3$	82	78	74	115	118	142	194	157
M-Alkalinity as $CaCO_3$	77	78	68	18	15	24	23	15
Turbidity as SiO_2	23.1	13.3	4.1	26.5	26.6	34.9	33.2	20.4
Copper as Cu	0	0	0	0.04	0.04	0.04	0.04	0.04
Total Iron as Fe	0.52	0.51	0.60	1.22	1.29	1.52	1.46	2.18
Chromates as CrO_4	-	-	-	-	-	-	-	21.98
Sulphate as (SO_4)	20	20	27	135	138	160	230	212
Suspended Solids	10.0	12.8	0.4	16.8	16.9	24.6	22.5	12.5
Manganese as Mn	0.04	0.04	0.04	0	0	0.16	0.31	0.02
Zinc as Zn	-	-	-	-	-	-	1.10	-
pH	7.53	7.59	6.82	6.79	6.79	6.60	6.12	6.07
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon, Compo T	Calgon-Corraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.595		$1.227	$1.786	$2.820
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	3.36		3.96	4.18	7.18

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - JUNE, 1956

P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP 'A'	'B'	'C'	'E'	'G'
Total Dissolved Solids	170	180	203	425	446	663	896	765
Meta-Phosphate as $NaPO_3$	0.27	0.55	0.07	4.71	5.78	9.06	7.65	4.45
Ortho-Phosphate as $NaPO_3$	0.32	0.34	0.05	7.70	7.92	9.45	12.62	9.68
Total Hardness as $CaCO_3$	124	122	129	204	210	309	429	346
Calcium as $CaCO_3$	74	72	81	115	130	199	258	214
M-Alkalinity as $CaCO_3$	102	103	85	19	15	13	15	16
Turbidity as SiO_2	10.3	10.2	3.9	29	28	44	63	26
Copper as Cu	0	0	0	0.04	0.04	0.04	0.04	0.04
Total Iron as Fe	0.45	0.45	0.51	1.14	1.17	1.42	1.58	2.13
Chromate as CrO_4	-	-	-	-	-	-	-	19.59
Sulphate as (SO_4)	19	20	32	163	175	150	239	214
Suspended Solids	6.8	8	0.5	16.8	16.8	28.5	42.3	14.8
Manganese as Mn	0.04	0.04	0.04	0	0	0.16	0.29	0.04
Zinc as Zn	-	-	-	-	-	-	1.00	-
pH	8.04	8.47	6.99	6.77	6.77	6.14	6.08	6.08
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.518		$1.680	$1.905	$2.502
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	2.89		5.26	4.49	6.30

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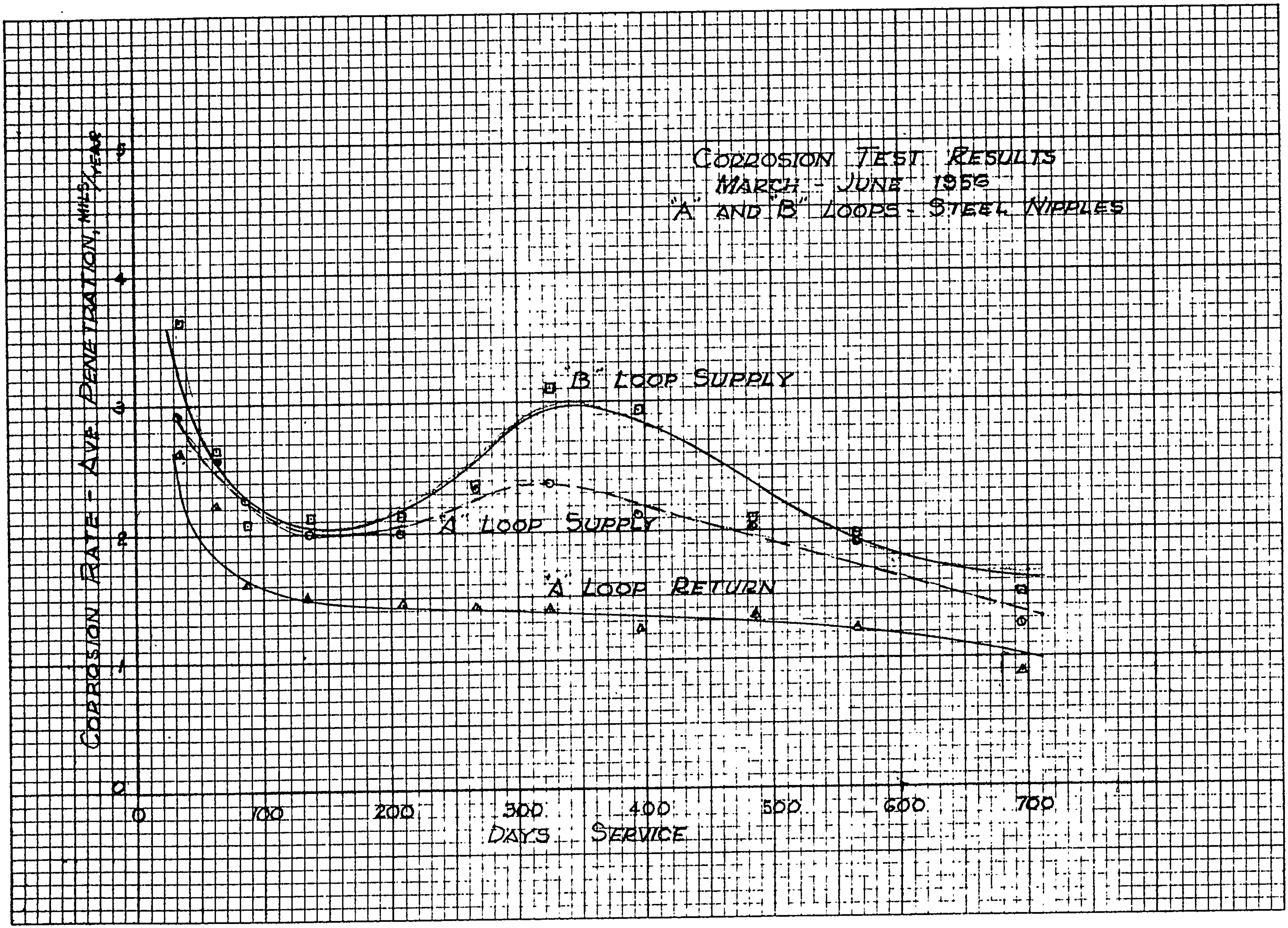

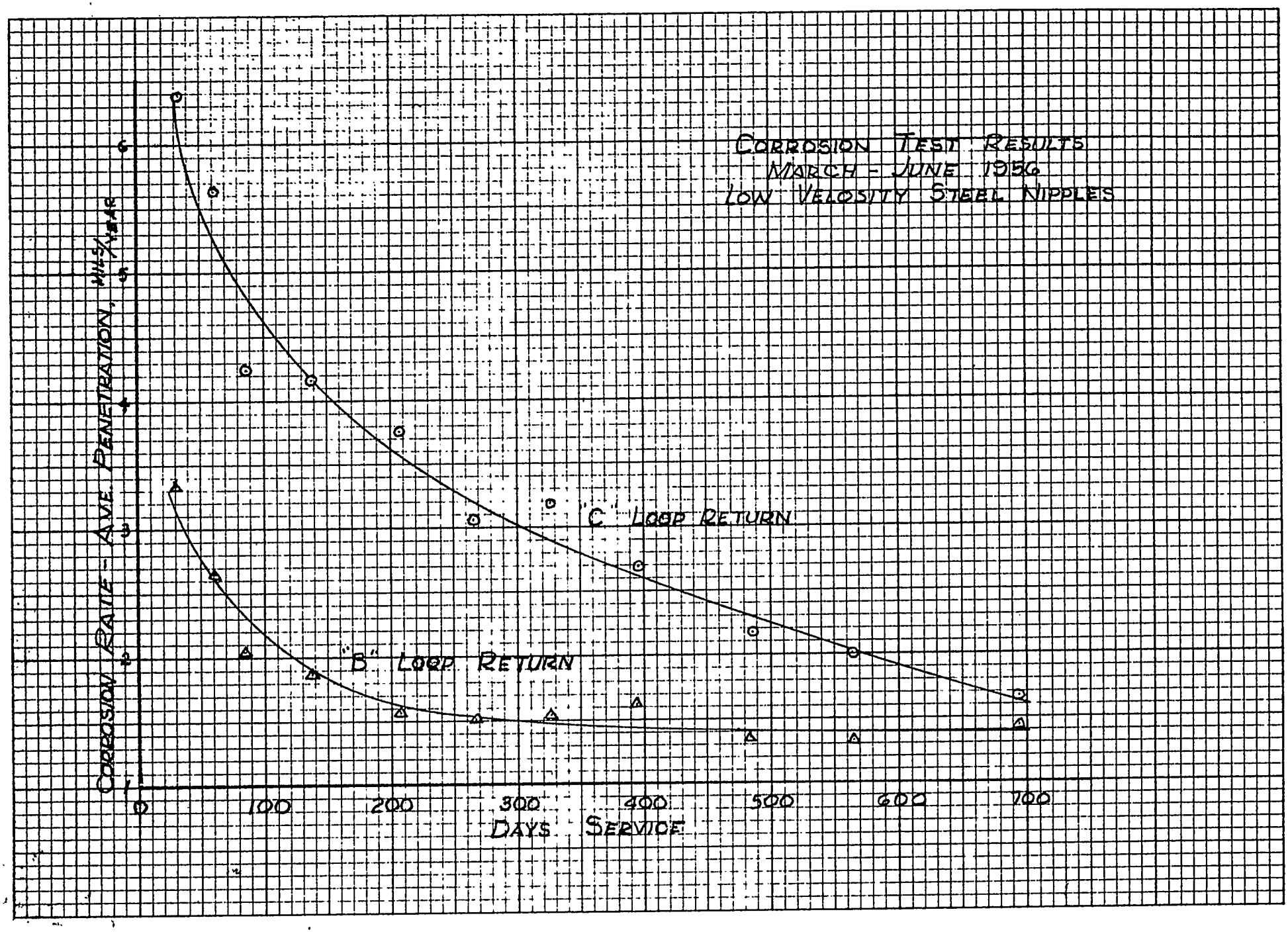

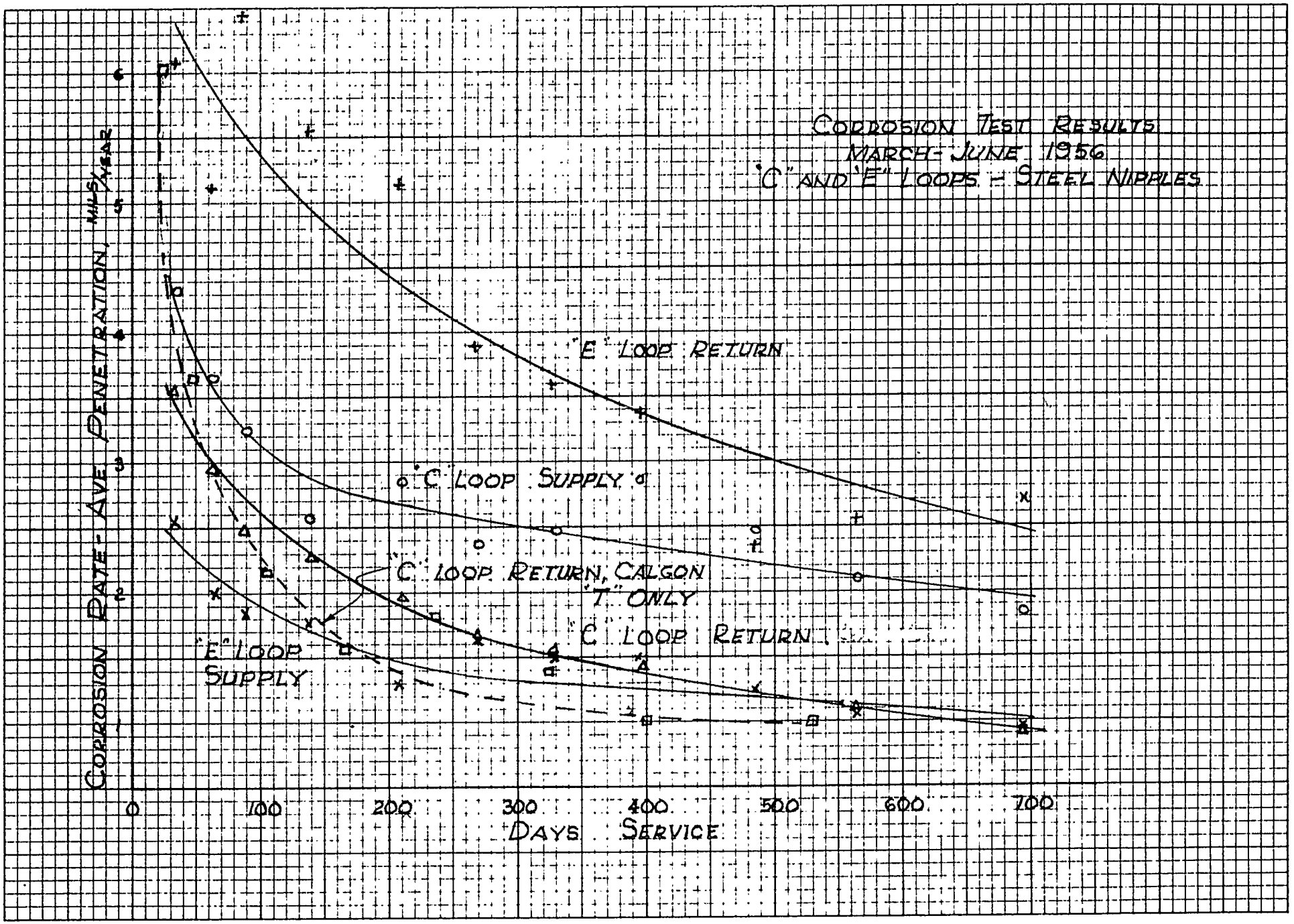

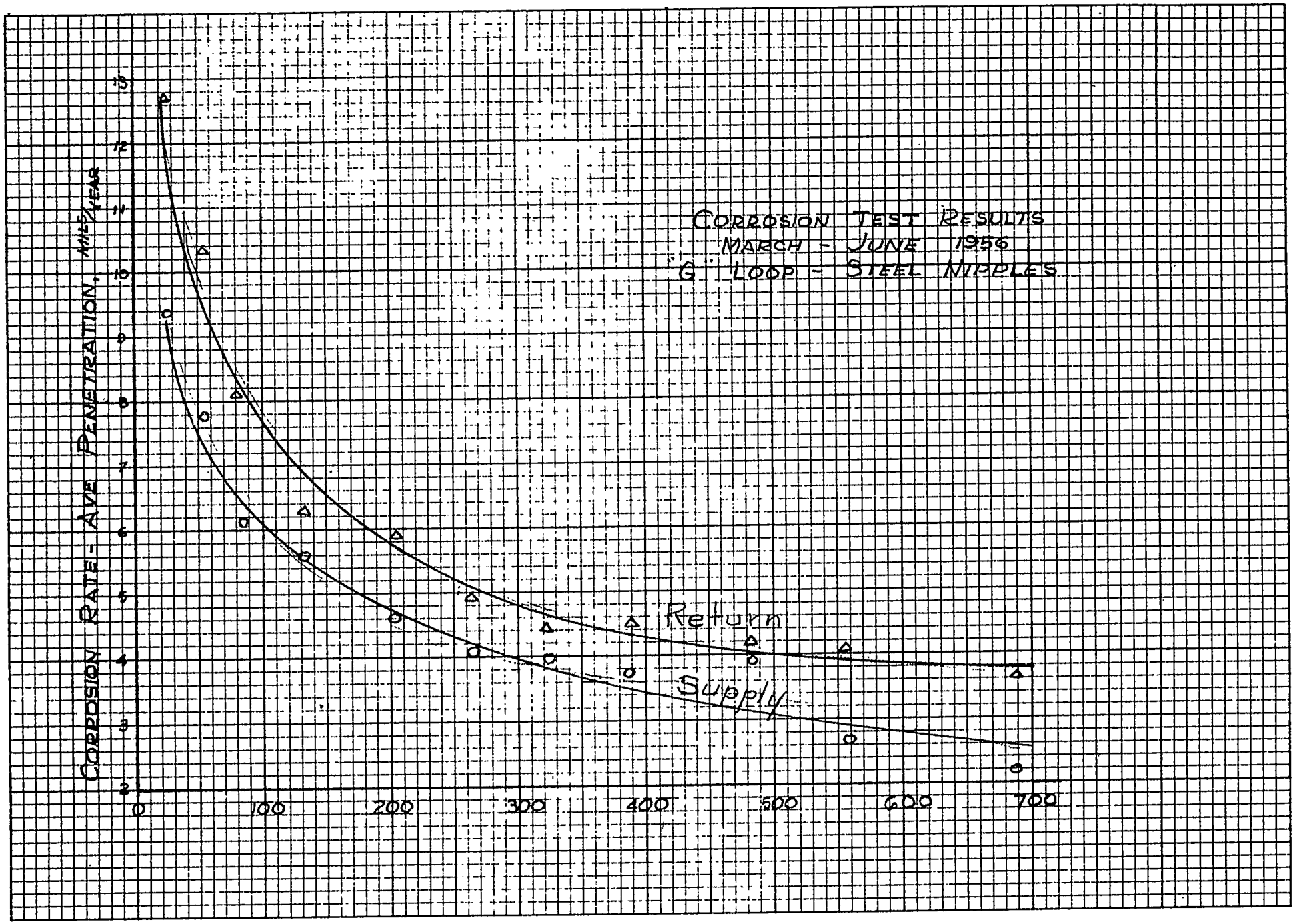

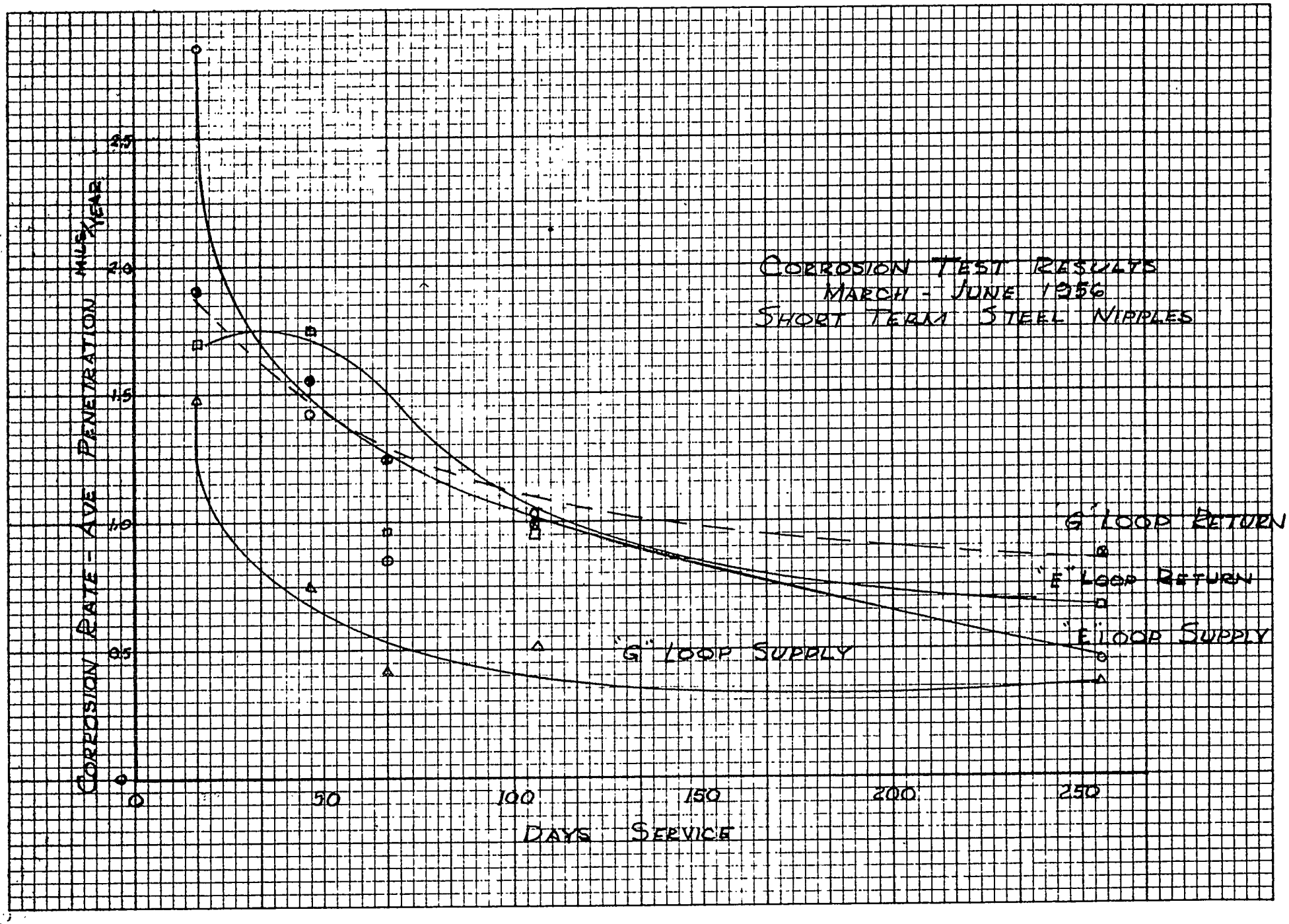

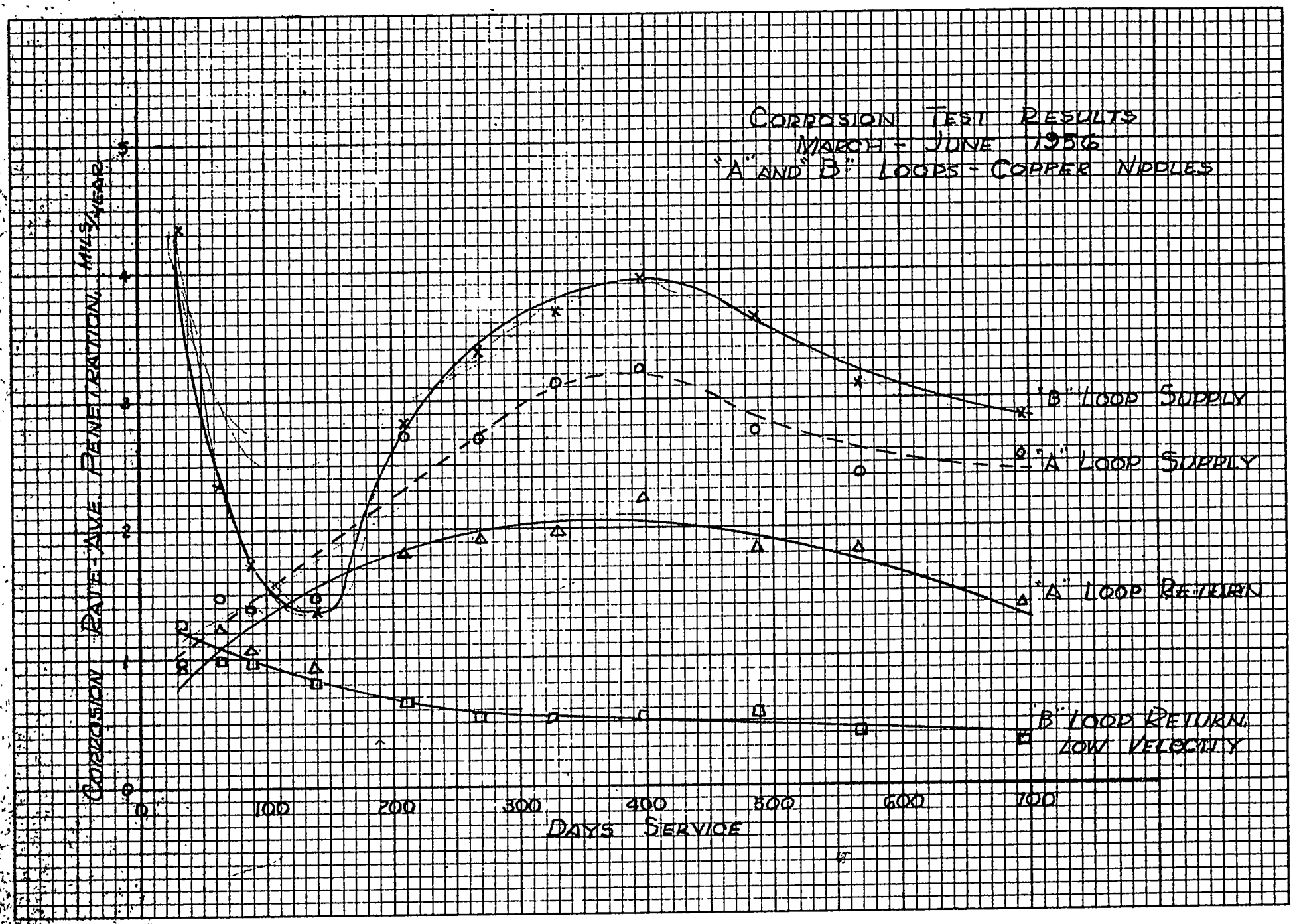

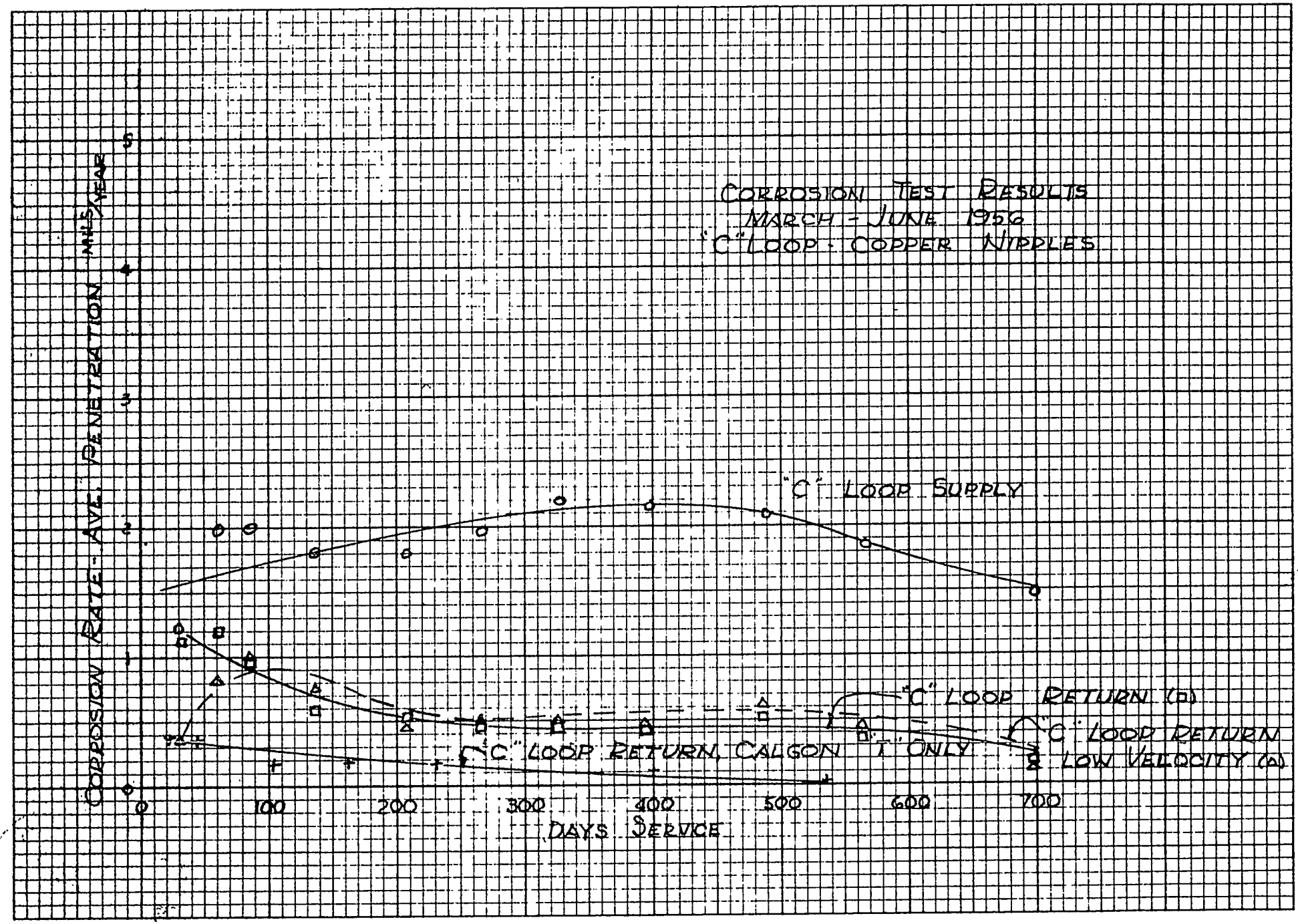

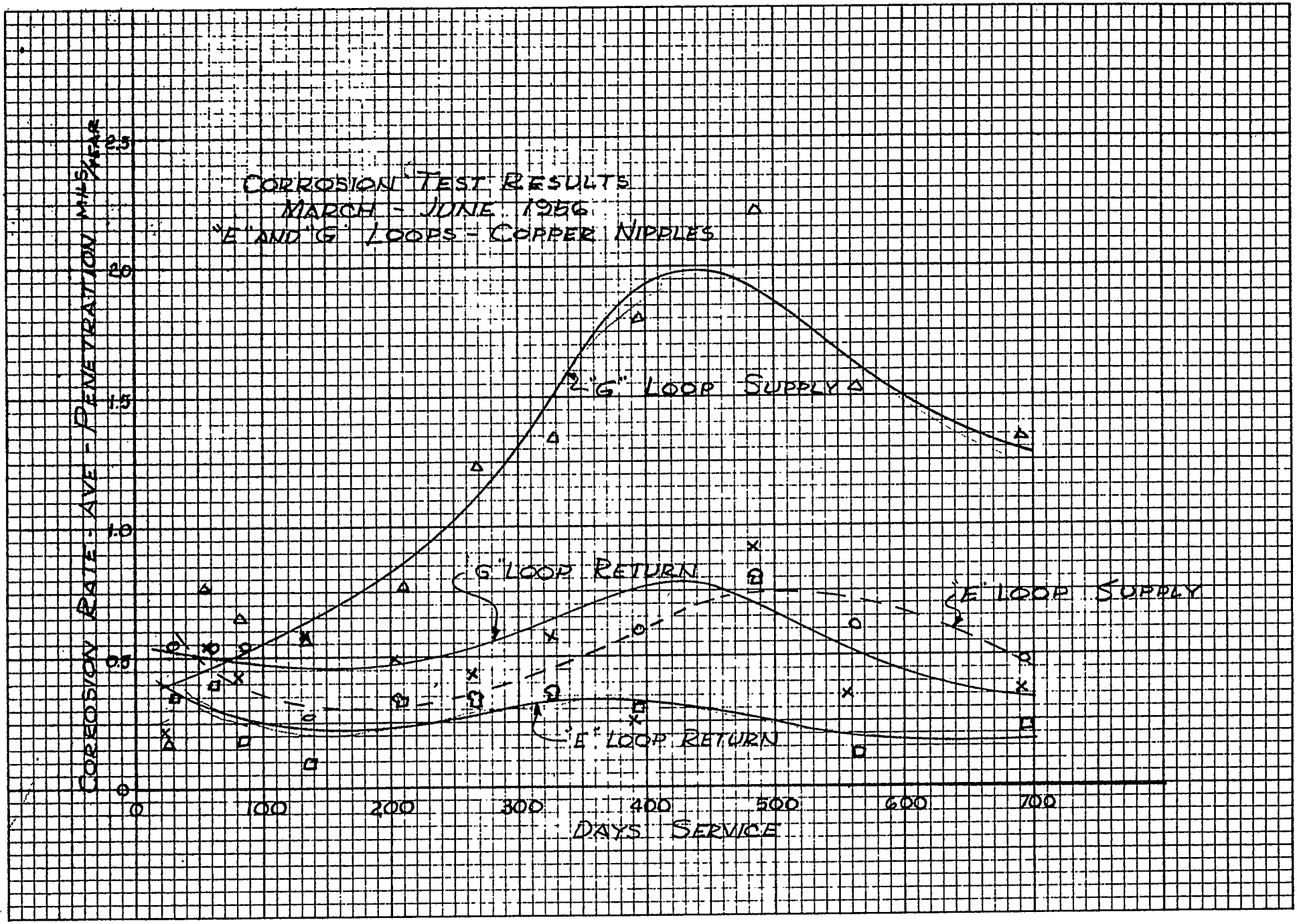

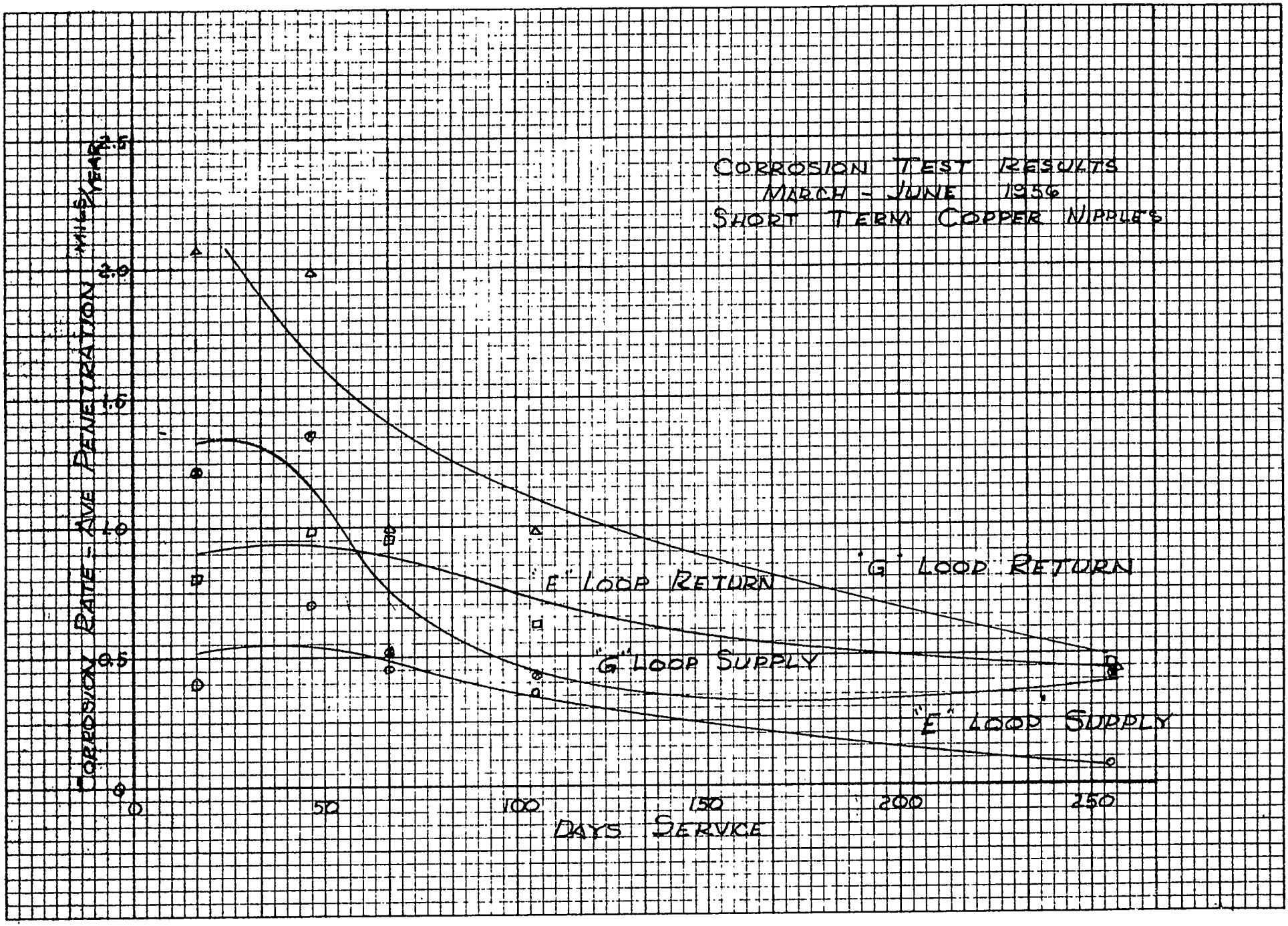

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Freon Condenser Corrosion

The most significant developments during this report period are as follows:

1) The K-31 process condensers show no additional corrosion for the last service year. The K-602-6.2 condenser was carefully examined by the Metallurgy Department for comparison with the K-602-3.5 condenser which was removed one year ago. Their report,[1] based on an exact basis of metal loss, and pit size and depth, concludes that the corrosive attack in the system has not progressed during the past year of service. It is of interest that plugged tubes of the K-602-6.2 condenser showed very scant pitting--indicating that the corrosion did not occur during the first twenty months of operation, prior to plugging.[2]

2) The high chromate test loop continues to give very good copper corrosion protection.[3] Only slight surface attack was found on standard copper, degreased standard copper, and oxidized and degreased standard copper tubes--all with 237 service days. Examination of four used tubes with 204 days' service indicates that the pits are no longer active. Only the pitting of the

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[1] Technical Division Weekly Report for the Week Ending August 31, 1956, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, September 3, 1956, (KLI-3800, Part 10). (Secret)

[2] Technical Division Weekly Report for the Week Ending August 24, 1956, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, August 27, 1956, (KLI-3800, Part 9). (Secret)

[3] Technical Division Weekly Report for the Week Ending July 20, 1956, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, July 23, 1956, (KLI-3800, Part 4). (Secret)

steel test nipples prevents the high chromate treatment from being acceptable corrosionwise. The high chromate test loop was discontinued on August 7, 1956. The Engineering Development Department is preparing a report of all results obtained with this treatment. Additional information on high chromate treatment will be obtained from the Utilities Department's new test loop, as will be described later in this report.

3) The K-801-A test condenser, which is now being used to evaluate the effects of unchlorinated make-up water, showed no pitting after a short run of 19 days.[4]

4) The K-31 supply test condenser, with heat load, is showing acceptable results.[5] The Metallurgy Department reports that cupronickel tubes with 187 and 222 service days and one standard copper tube with 253 service days showed slight pitting. The remaining six tubes examined, including degreased standard tubes, annealed arsenical copper tubes, and air-oxidized annealed arsenical copper tubes with 187 and 222 service days showed only general surface attack and no pits.

5) The K-33 supply test condenser, with heat load, is giving very good results.[6] Ten tubes removed from six test condensers show no evidence of pitting. The tubes examined included five annealed arsenical copper specimens with 163 to 181 service days at velocities of 3 to 17 feet per second, an annealed arsenical copper tube with 41 service days, a cupronickel tube with 134 service days, and the following with 170 service days: a standard degreased copper tube, a standard degreased water-oxidized copper tube, and an admiralty brass tube.

6) As previously, the K-31 return water test condenser, with no heat load, is giving comparatively poor results.[7] An annealed arsenical copper tube and a standard degreased copper tube with 142 service days showed numerous pits with a maximum diameter of 1/32 inch. Seven of nine tubes removed from this condenser have been pitted. It is believed that the pitting of this condenser occurred during intial period of Coraid treatment when the pH of the recirculating water would go as low as 4.0 during intermittent chlorination periods. The process condensers and test condensers with heat load have not shown any

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[4](KLI-3800, Part 9), op. cit. (Secret)

[5](KLI-3800, Part 4), op. cit. (Secret)

[6]Technical Division Weekly Report for the Week Ending July 6, 1956, (KLI-3800, Part 2). (Secret)

[7]Technical Division Weekly Report for the Week Ending July 13, 1956, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, July 16, 1956, (KLI-3800, Part 3). (Secret)

appreciable corrosion since starting Coraid treatment, and it is believed that they had enough deposition to protect them from short periods of low pH and no Coraid. The poor pH control during periods of chlorination has been corrected, and the attached copper corrosion curves show the importance of this improvement on copper test nipples which also have no heat load.

7) The K-29 supply test condenser, with heat load, is giving fair results. Small pits with extensive areas of slight to moderate surface attack have been found in four tubes. These tubes with days of service are as follows: aluminum-brass (69), cupronickel (160), standard copper (196), and standard copper degreased (196).[8] Three tubes with 160 service days show no pits and only small areas of slight surface attack. These latter tubes are annealed arsenical copper, standard degreased copper, and water-oxidized standard degreased copper.

Tests and operating results of the individual loops are as follows:

A Loop (K-25 East)

With "A" and "B" loops tied together for greater operational safety and flexibility, it is no longer possible to determine accurately the portion of the K-25 pumpage that is delivered to either "A" or "B" loop individually. However, it is known that there were no significant changes during this report period in the "A" loop heat transfer characteristics, as the combined "A" and "B" pumpages remained unchanged at 67 million gallons per day, the "A" loop average water control valve position as recorded in K-309-2 was unchanged at 45 per cent open, and the return water temperature increased 1° F to 121° F.

B Loop (K-25 West)

There were indications of slight improvement in the "B" loop heat transfer characteristics, as the return water temperature increased 2° F to 107° F, and the average water control valve position as measured in K-304-4 closed from about 38 per cent open to 33 per cent open.

C Loop (K-27/K-29)

There are indications of some loss of heat transfer characteristics for this period, as pumpage requirements increased from 55 to 60 million gallons per day with about 1.5° F drop in return water temperature. Apparently this heat transfer loss occurred in K-29 where the average water control valve position as indicated in K-502-1 opened from 30 to 32 per cent open, as compared to K-27 where the average water control valve position as indicated in K-402-3 was constant at 62 per cent open.

For some unknown reason, the Calgon-Coraid treatment as being used on

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[8] Ibid.

"C" loop is not giving as good copper corrosion results on test nipples as those obtained on "E" loop. The latest "C" loop copper corrosion rate of 0.83 mil per year after 79 service days is not too bad, but when compared to the 0.30 mil per year after 21 service days and the latest "E" loop rate of less than 0.01 mil after 103 days, it seems at least comparatively bad. It may be that the "C" loop Coraid feed point to a slowly moving large body of water will not be satisfactory. On "E" loop, Coraid is added to a special mixing compartment with very high water velocities. This aspect is being investigated.

There were no additional failures of the K-29 "modified" condensers during this report period.

E Loop (K-31)

The Calgon-Coraid treatment, originally unsatisfactory, is now beginning to look very good. The reasons for this modified opinion are as follows:

1) As previously mentioned, recent examination of a K-31 process condenser (K-602-6.2) indicates no additional corrosion during the past year.

2) The most recent copper corrosion rates are at the unbelievably low value of less than 0.01 mil per year for both 45 and 103 service days. Actually, the test nipples installed after improving the chlorination precedure, and about 70 days before increasing the Coraid feed rate, give a very low copper corrosion rate of 0.04 mil per year which may indicate that the original feed rate would be satisfactory under good operating conditions.

3) Assuming that the serious copper corrosion was primarily due to the Nalco water treatment, K-31 condenser failures after 92 days of Nalco service are practically nil; whereas K-33, Paducah, and the one Portsmouth system also exposed to Nalco are having repeated failures. The Nalco water treatment at K-33 was used only 82 days; however, this was during the more critical start-up period.

There is indication of some loss of heat transfer during this report period, as pumpage requirements increased from 72.5 to 75.5 million gallons per day, and the return water temperature decreased 1° F to 146.5° F. The average water control valve position, as recorded in K-602-3, was constant at 46 per cent open.

There were no condenser failures during this report period.

As regarding steel corrosion, a recent report[9] from Metallurgy shows

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[9] Letter from C. R. Barlow and W. W. Latham, Metallurgy Department, Technical Division, to C. C. Fowlkes entitled "K-31 and K-33 Water Lines," dated September 6, 1956, (KLI-3871).

severe loss of metal (maximum of 30 per cent of original wall thickness) in a spool piece from K-602-4, cell 5. Until confirmed by additional specimens, this loss is not accepted as being representative of process piping. The reasons for believing the specimen submitted to Metallurgy is not representative are as follows:

1) The spool piece in question was installed in the condenser outlet water line on the fully instrumented cell and is the only such piece of test pipe in K-31. The wall thickness was not positively known and was assumed to be the same as other 8" water piping. Since this was a specially fabricated section, it is possible that it was made from different stock material.

2) Some of the K-31 Operation Group think that the fully instrumented cell was individually acid-cleaned, possibly several times, shortly after start-up. This has not been confirmed, but early operations did cause considerable scaling at high recirculating water pH's then being used.

3) All previously submitted specimens from K-31 have shown good resistance to corrosion. It is true that most of these specimens have been cast iron elbows, which may also not be representative. However, the last report shows that a section of 4" return line from the P & E station had lost only a maximum of 8 per cent of its nominal wall thickness. This section of piping, with 3½ service years, had been exposed to what is believed to be the most critical service conditions of K-31 operating history, as all four "acid-cleanings" and the Nalco trial run occurred during its service life. These periods are believed most critical, as the copper pickup, which can cause severe pitting by deposition on steel, was highest during these times. In any case, the K-31 actual steel corrosion rate will be rechecked at the first opportunity.

G Loop (K-33)

There was apparently some loss in heat transfer, as pumpage requirements increased from 218 to 225 million gallons per day with 1° F drop in return water temperature to 151° F. The average water control valve position as indicated in K-902-4 opened from 65 to 70 per cent open. The heat transfer loss in both "E" and "G" loops is attributed to higher hardness in the make-up water.

All "G" loop corrosion rates are very good. The Betz dianodic is apparently doing a good job, and the number of condenser failures are much fewer than originally expected. There were only two process condenser failures during the report period. They are as follows:

1) K-902-1.9 odd - Leakage of 4 pounds per day - five tube sheet leaks.

2) K-902-3.3 odd - Plugged 13 tubes and repaired 10 tube sheet leaks.

New Utilities Department Test Loop

A new recirculating water test loop, located at K-892, was placed in service in August. This test loop was constructed to replace the temporary test systems located in K-892 and K-801-A and will allow closer simulation of actual operating conditions that may be encountered in the various recirculating water systems. The old test loops could not adequately simulate these conditions since no provision was made for concentrating the recirculating water; the new test loop is equipped with a Marley "Aquaflow" cooling tower to permit this concentration. The attached pictures and flow diagram show the details of the new test loop.

The initial test, to determine corrosion rates and heat transfer rates, is now in progress under the following conditions:

Concentration Ratio	10:1
Supply Temperature	95° F
Return Temperature	150° F
pH	6.5
Chromate Concentration, CrO_4	500 ppm.

The first results of this test loop will be in the following report.

Monthly Average Water Analyses

Attached are separate monthly average water analyses sheets for each month covered by this report. The major changes from the previous report are large increases in hardness and total dissolved solids of the make-up water, which are also reflected in the recirculating water analyses.

Graphs of Steel and Copper Corrosion Rates

Attached are two "short-term" corrosion test curves. One of these curves is for steel on "E" and "G" loops, and the other for copper for same loops. These are the best test results ever obtained at ORGDP.

C. C. Fowlkes

C. C. Fowlkes

Approved: K. M. Jones

K. M. Jones
Process Utilities Department

MONTHLY AVERAGE WATER ANALYSES - JULY, 1956

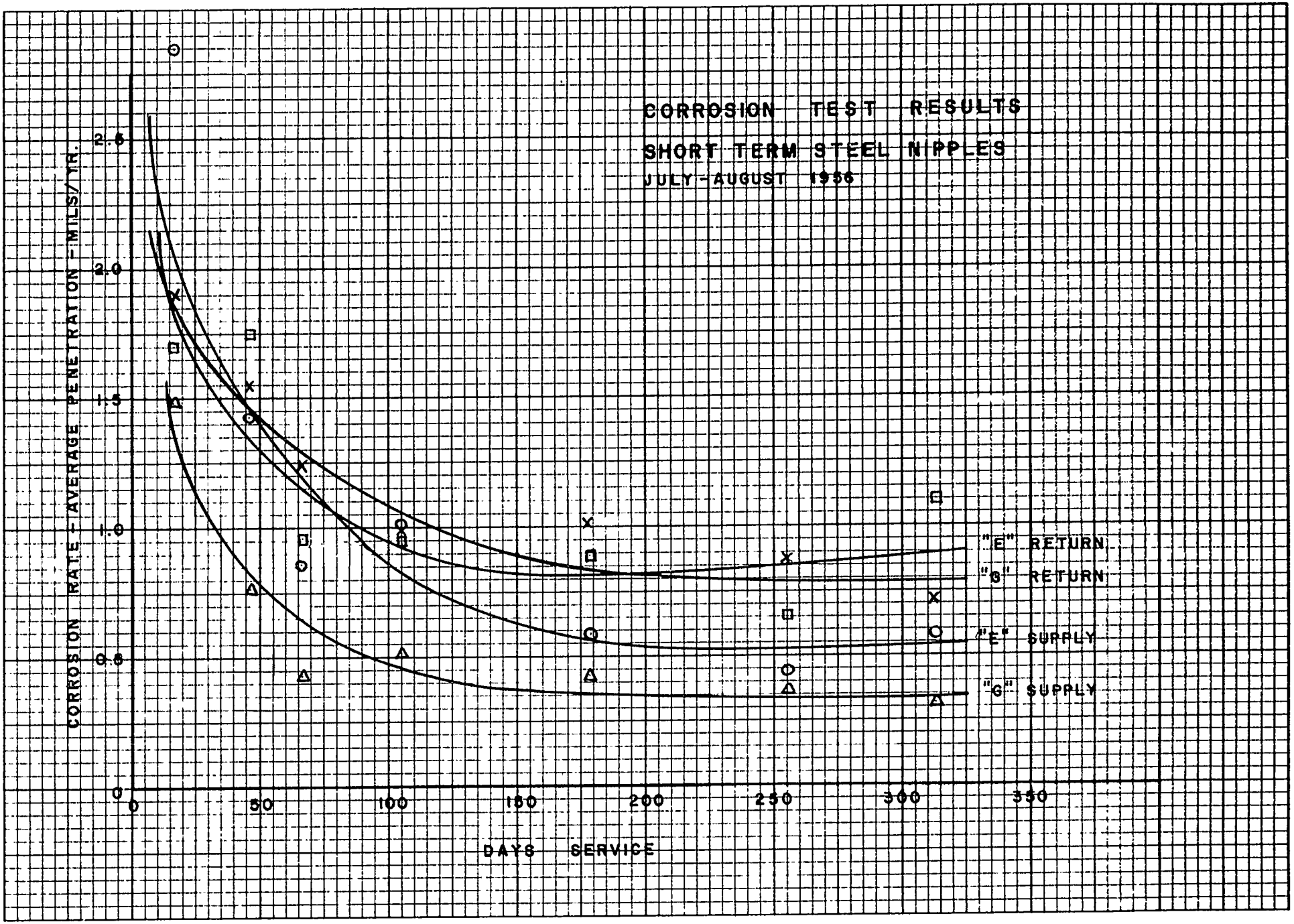
P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP 'A'	'B'	'C'	'E'	'G'
Total Dissolved Solids	189	238	254	453	453	744	914	926
Meta-Phosphate as $NaPO_3$	0.38	0.25	0.44	4.47	4.33	8.25	7.82	5.18
Ortho-Phosphate as $NaPO_3$	0.83	1.31	0.19	8.02	7.98	9.00	11.2	12.15
Total Hardness as $CaCO_3$	115	137	129	207	202	330	417	381
Calcium as $CaCO_3$	82	96	88	143	145	216	282	267
M-Alkalinity as $CaCO_3$	87	92	73	17	18	13	13	17
Turbidity as SiO_2	19	43	6	32	32	52	62	39
Copper as Cu	0	0	0	0.04	0.14	0.04	0.04	0.04
Total Iron as Fe	0.61	1.16	0.41	2.05	2.09	2.78	3.38	3.72
Sulphate as (SO_4)	16	68	50	168	194	256	375	254
Chromates as CrO_4	-	-	-	-	-	-	-	26.8
Suspended Solids	10	24	2.40	19	19.42	35	46	26
Manganese as Mn	0.04	0.04	0.03	0.026	0.036	0.16	0.29	0.04
Zinc as Zn	-	-	-	-	-	-	1.41	-
pH	7.72	7.79	6.82	6.75	6.76	6.10	6.06	6.06
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.679		$1.681	$2.078	$2.654
Total Chemical Treatment Costs in Mils per MM BTU Removed				3.57		5.28	4.87	6.56

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - AUGUST, 1956

P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP 'A'	'B'	'C'	'E'	'G'
Total Dissolved Solids	272	281	309	493	483	775	876	1092
Meta-Phosphate as $NaPO_3$	0	0.4	0.1	6.25	7.64	8.66	6.64	5.51
Ortho-Phosphate as $NaPO_3$	0.66	1.1	0.15	9.51	9.67	10.05	10.51	13.29
Total Hardness as $CaCO_3$	129	136	138	206	208	335	372	449
Calcium as $CaCO_3$	92	98	93	146	148	215	259	303
M-Alkalinity as $CaCO_3$	113	101	94	17	17	10	12	16
Turbidity as SiO_2	9.1	9.1	3.7	24	23	38	43	35
Copper as Cu	0	0	0	0.06	0.08	0.04	0.04	0.04
Total Iron as Fe	0.51	0.58	0.42	1.77	1.72	3.48	3.41	3.98
Sulphate as (SO_4)	24	30	39	148	152	249	295	258
Chromates as CrO_4	-	-	-	-	-	-	-	31.3
Suspended Solids	6	10	2	13	12	23.1	29	22
Manganese as Mn	0.04	0.04	0.04	0.07	0.08	0.18	0.30	0.04
Zinc as Zn	-	-	-	-	-	-	1.73	-
pH	7.87	7.98	7.10	6.76	6.79	6.11	6.01	6.08
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.692		$1.595	$1.935	$2.360
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	3.58		5.13	4.55	6.06

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.


CORROSION TEST RESULTS
SHORT TERM STEEL NIPPLES
JULY-AUGUST 1956
CORROSION RATE - AVERAGE PENETRATION - MILS/YR.
2.5
2.0
1.5
1.0
0.5
0
0
50
100
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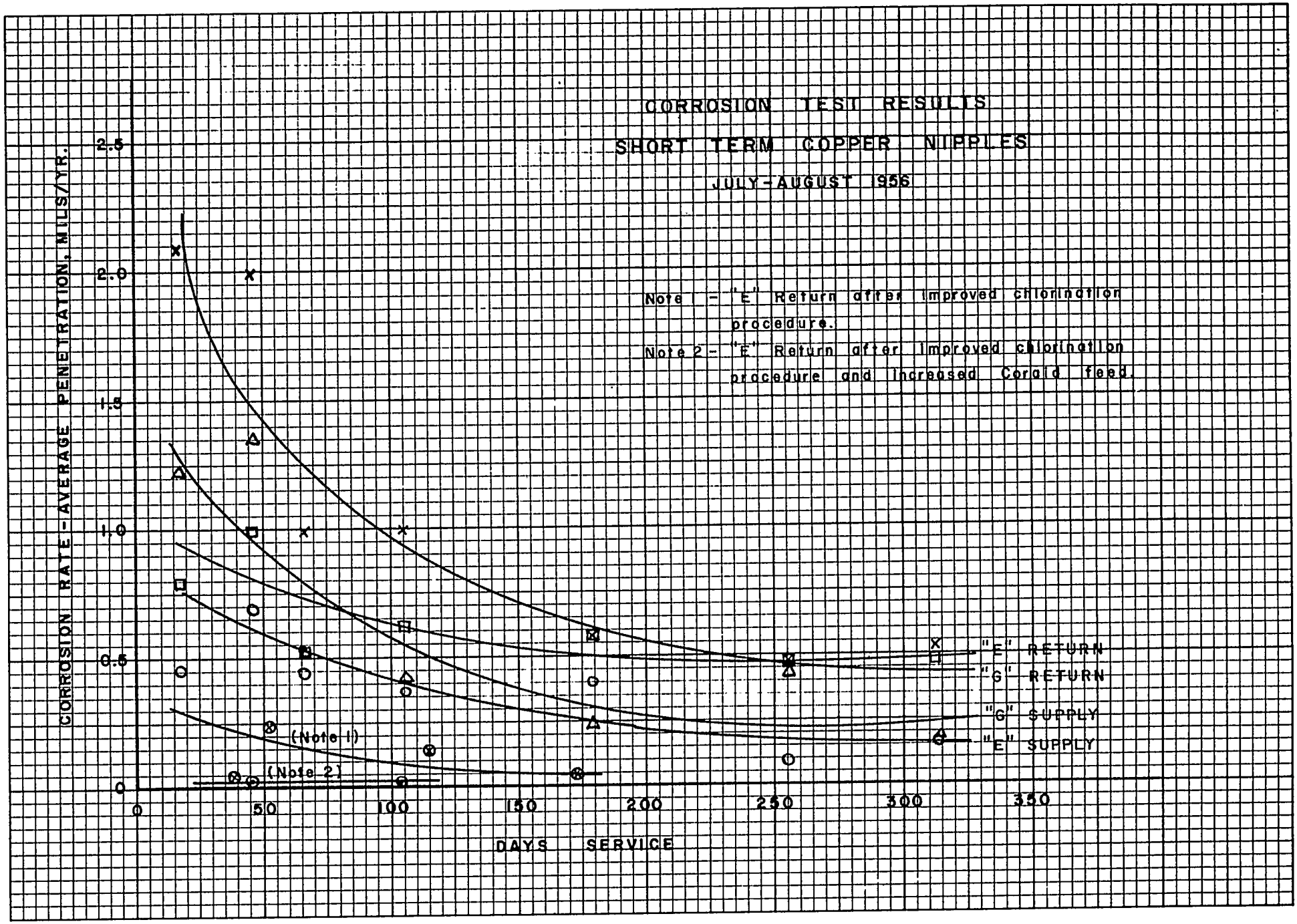
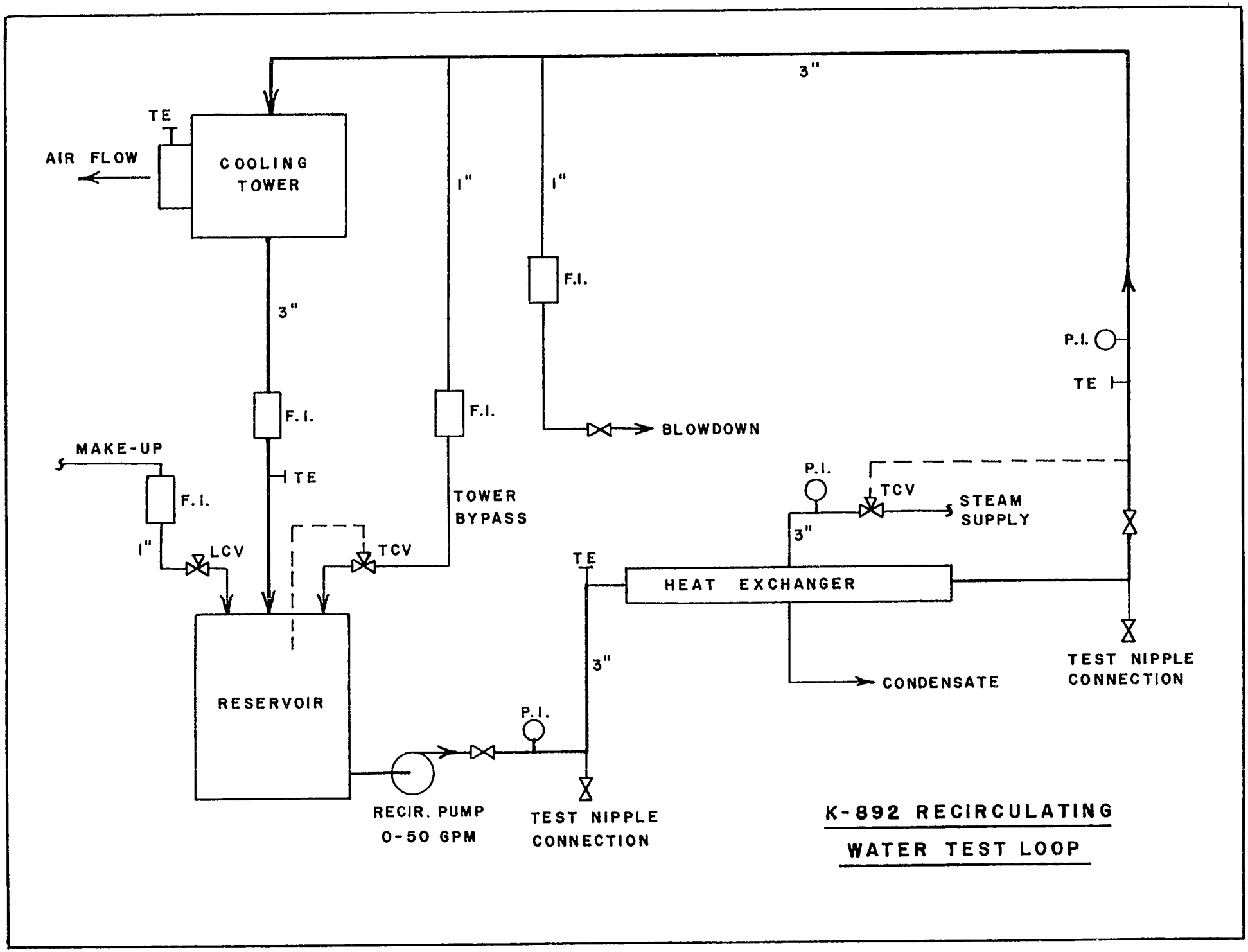
200
250
300
350
DAYS SERVICE
"E" RETURN
"G" RETURN
"E" SUPPLY
"G" SUPPLY


CORROSION TEST RESULTS
SHORT TERM COPPER NIPPLES
JULY-AUGUST 1956
Note 1 - "E" Return after improved chlorination procedure.
Note 2 - "E" Return after improved chlorination procedure and increased Corald feed.
CORROSION RATE-AVERAGE PENETRATION, MILS/YR.
2.5
2.0
1.5
1.0
0.5
0
(Note 1)
(Note 2)
"E" RETURN
"G" RETURN
"G" SUPPLY
"E" SUPPLY
0
50
100
150
200
250
300
350
DAYS SERVICE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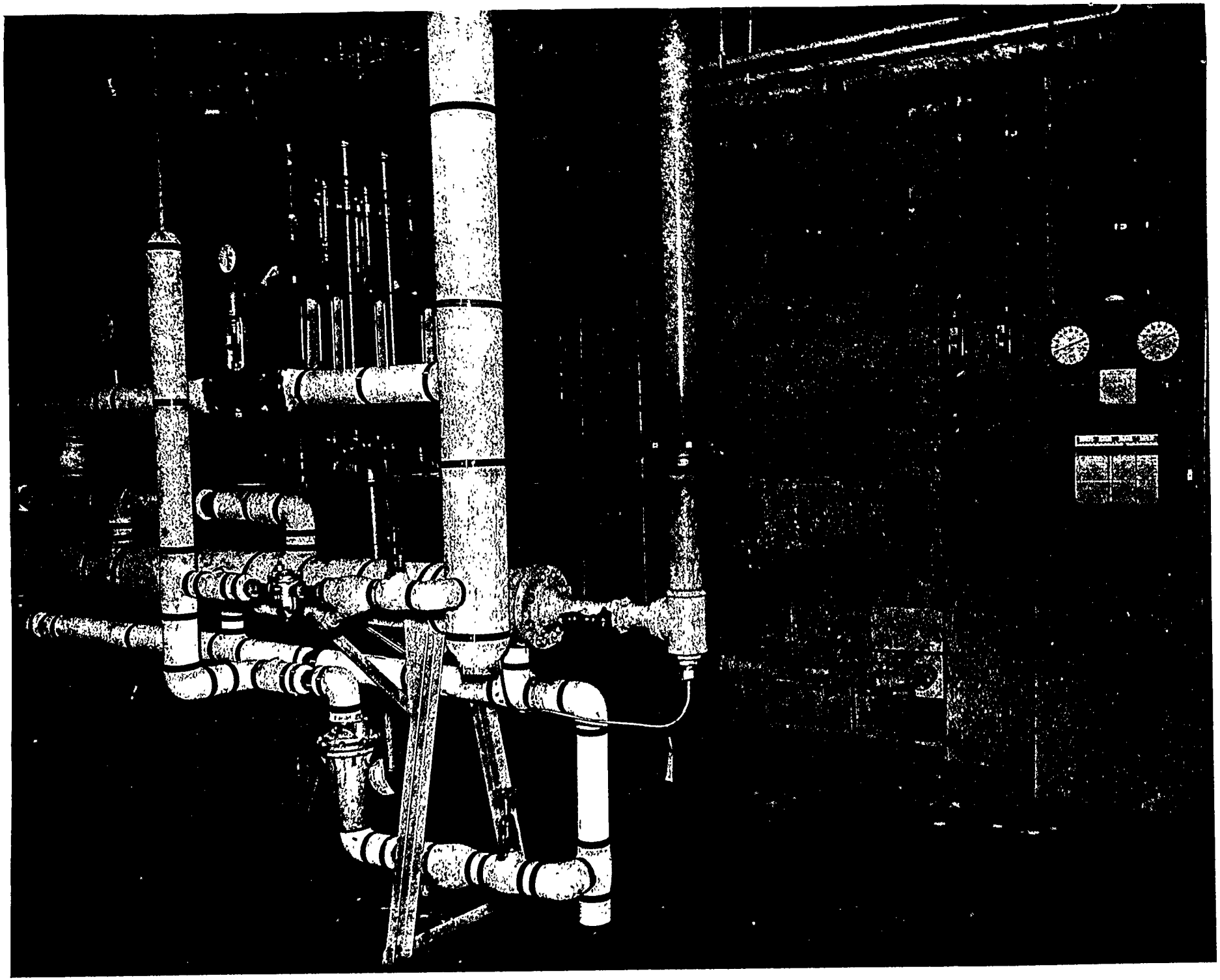
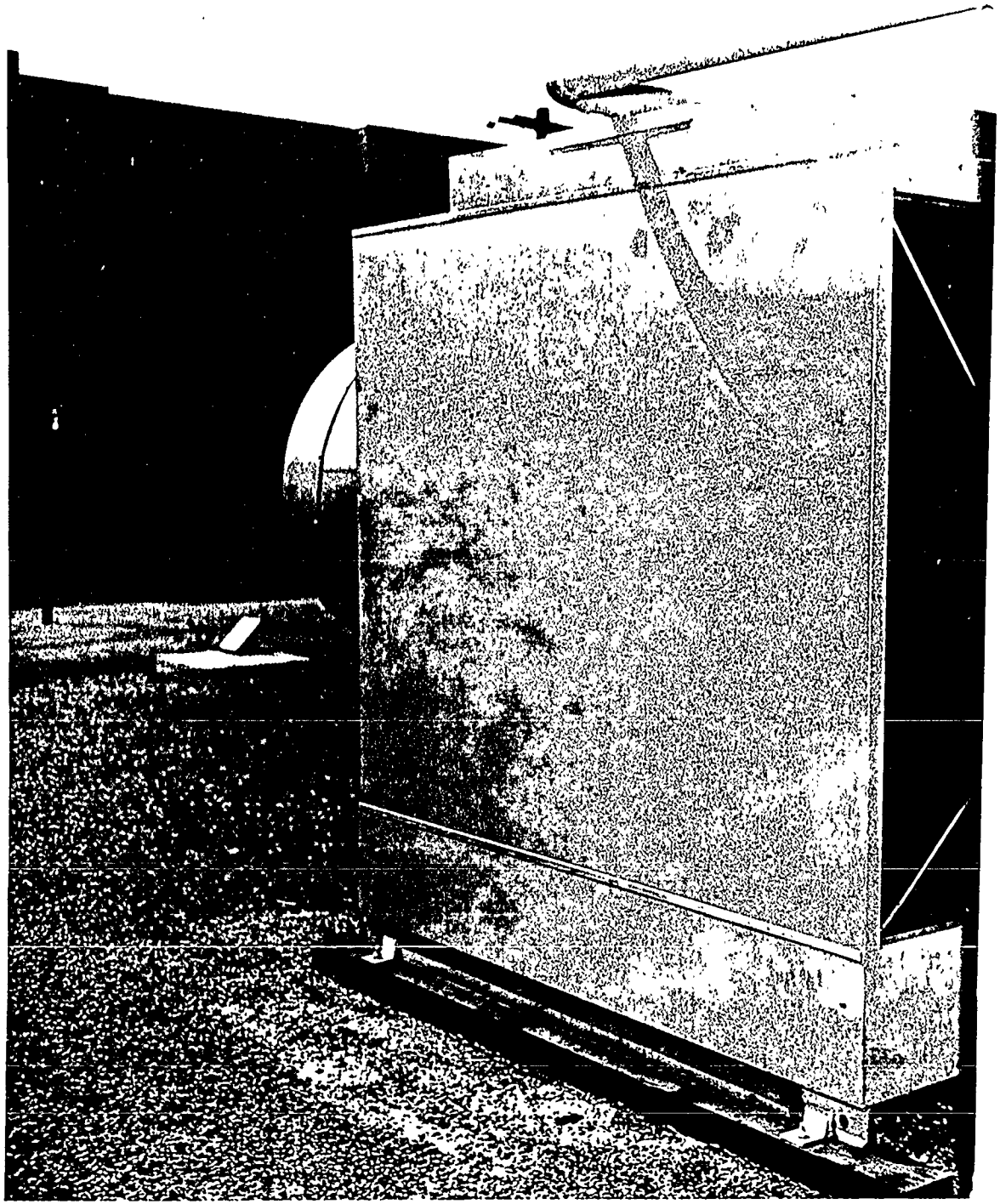
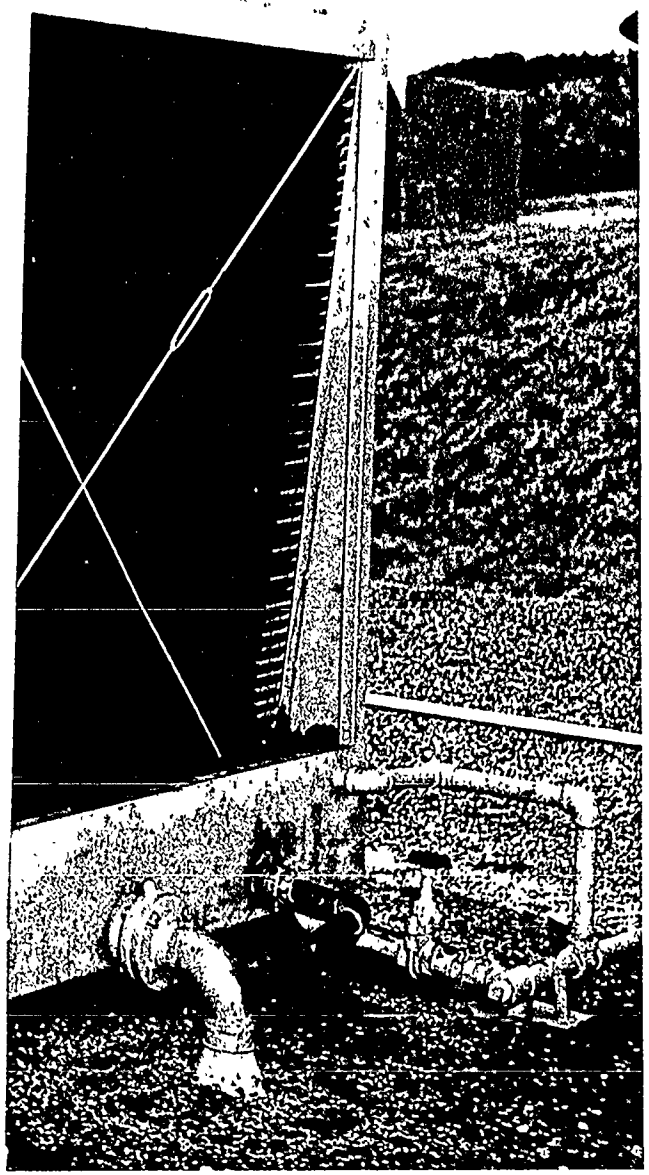
AIR FLOW
COOLING TOWER
3"
1"
1"
F.I.
3"
F.I.
F.I.
BLOWDOWN
P.I.
TE
MAKE-UP
F.I.
TE
TOWER BYPASS
P.I.
TCV
STEAM SUPPLY
1"
LCV
TCV
3"
TE
HEAT EXCHANGER
RESERVOIR
3"
CONDENSATE
TEST NIPPLE CONNECTION
P.I.
RECIR. PUMP 0-50 GPM
TEST NIPPLE CONNECTION
K-892 RECIRCULATING
WATER TEST LOOP







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Report Number: KP-570, Part No. 19

UNION CARBIDE NUCLEAR COMPANY

Production Division

Utility Operations Department

SUMMARY OF RECIRCULATING WATER TREATMENT TESTS FOR SEPTEMBER AND OCTOBER, 1956

C. C. Fowlkes

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Snyder, H. G. P.
Sternberg, E. O.

Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, Operating Contractor for the U.S. Atomic Energy Commission.

INTER-COMPANY CORRESPONDENCE

(INSERT NAME) COMPANY CARBIDE AND CARBON CHEMICALS COMPANY LOCATION Post Office Box P OAK RIDGE, TENN.

TO Mr. H. G. P. Snyder
LOCATION K-303-8

DATE January 29, 1957

ANSWERING LETTER DATE

ATTENTION

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SUBJECT Summary of Recirculating Water Treatment Tests for September and October, 1956

KP-570, Part No. 19

In addition to discussions of operating results of all recirculating water systems, this report contains the usual "long-term" corrosion curves and "short-term" corrosion curves for the K-31 and K-33 recirculating water systems. Also included is a discussion and a graph of operating results obtained from pilot plant continuous softening of Clinch River water.

Freon Condenser Corrosion

The most significant developments during this report period are as follows:

1) Conclusions have been achieved from the test of high-chromate dianodic water treatment (200 ppm. chromate, 20 ppm. phosphate, with a pretreatment of 500 ppm. chromate for seven days). The tests were conducted in conjunction with the Laboratory and Engineering Development Departments and major points are as follows:[1]

   a) This treatment was effective in eliminating pitting in new copper tubes; stopping pitting in used, acid cleaned tubes; and appeared to slow down the attack in pits of used, uncleaned tubes. No significant advantage of this treatment over the Betz dianodic treatment was found with respect to inhibiting pitting-type corrosion in new copper tubes or in used, uncleaned tubes. Slight advantage of the high-chromate treatment over the Betz treatment in preventing further pitting in used, acid-cleaned tubes was indicated. In both cases it was found that acid cleaning of used, pitted tubes was beneficial in retarding or preventing further pitting.

   b) There was no appreciable difference in quantity of scale deposition or the over-all coefficient of heat transfer of test condensers operating on Betz treatment and high-chromate

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[1] Technical Division Weekly Report for the Week Ending September 21, 1956, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, September 24, 1956, (KLI 3800, Part 13). (Secret)

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1 Aiken
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3 Miller
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UNION CARBIDE NUCLEAR COMPANY

Production Division

Utility Operations Department

SUMMARY OF RECIRCULATING WATER TREATMENT TESTS FOR SEPTEMBER AND OCTOBER, 1956

C. C. Fowlkes

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Sternberg, E. O.

INTER-COMPANY CORRESPONDENCE

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TO Mr. H. G. P. Snyder
LOCATION K-303-8

DATE January 29, 1957

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In addition to discussions of operating results of all recirculating water systems, this report contains the usual "long-term" corrosion curves and "short-term" corrosion curves for the K-31 and K-33 recirculating water systems. Also included is a discussion and a graph of operating results obtained from pilot plant continuous softening of Clinch River water.

Freon Condenser Corrosion

The most significant developments during this report period are as follows:

1) Conclusions have been achieved from the test of high-chromate dianodic water treatment (200 ppm. chromate, 20 ppm. phosphate, with a pretreatment of 500 ppm. chromate for seven days). The tests were conducted in conjunction with the Laboratory and Engineering Development Departments and major points are as follows:[1]

   a) This treatment was effective in eliminating pitting in new copper tubes; stopping pitting in used, acid cleaned tubes; and appeared to slow down the attack in pits of used, uncleaned tubes. No significant advantage of this treatment over the Betz dianodic treatment was found with respect to inhibiting pitting-type corrosion in new copper tubes or in used, uncleaned tubes. Slight advantage of the high-chromate treatment over the Betz treatment in preventing further pitting in used, acid-cleaned tubes was indicated. In both cases it was found that acid cleaning of used, pitted tubes was beneficial in retarding or preventing further pitting.

   b) There was no appreciable difference in quantity of scale deposition or the over-all coefficient of heat transfer of test condensers operating on Betz treatment and high-chromate

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[1] Technical Division Weekly Report for the Week Ending September 21, 1956, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, September 24, 1956, (KLI 3800, Part 13). (Secret)

treatment.

c) In test condensers operated at different water velocities, there was no significant variation in the amount of surface attack or in the formation of pits on the condenser tubes. The quantity of scale deposited appeared to be independent of velocity but was smoother and denser at the higher velocities. The over-all coefficient of heat transfer was much greater in the test condensers operating at the higher velocities, but this condition existed only during the period of high-velocity operation.

d) The standard phosphorus-deoxidized and the arsenical inhibited copper tubes had the greatest resistance to pitting-type corrosion of the materials evaluated in the test condensers. The various types of brass tubes were attacked by preferential removal of one of the alloying materials, and the cupronickel tubes had the highest incidence of pitting of all the materials tested.

Tests are continuing in the K-892 test loop to evaluate a similar treatment using 500 ppm. chromate.

2) The high-chromate dianodic (200 ppm. chromate, 20 ppm. phosphate) water treatment without the pretreatment of 500 ppm. chromate for seven days did not stop pitting in all used, acid-cleaned tubes, as one (196 service days) was found with numerous large active pits and tubercles.[2] Also with the same treatment, three used, uncleaned tubes with 112 to 196 days had active pits and tubercles.

3) Cathodic protection for heat exchanger tubes is being studied.[3] Todate any application of current (0 - 20 milliamperes per square foot) resulted in a deposit of material at the anode end of the tubes, using recirculating water. Additional tests are now underway using untreated Poplar Creek water.

4) Continued good results are being obtained from the K-33 test condensers using Betz dianodic treatment.[4]

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[2] Technical Division Weekly Report for the Week Ending October 19, 1956, (KLI 3800, Part 17). (Secret)

[3] Technical Division Weekly Report for the Week Ending September 14, 1956, (KLI 3800, Part 12). (Secret)

[4] Technical Division Weekly Report for the Week Ending October 26, 1956, (KLI 3800, Part 18). (Secret)

5) No pits have been found in the K-801-A test condenser tubes using unchlorinated Poplar Creek water. Additional manganese has been added to maintain 1.0 ppm.[5,6,7] If no pits are found in the near future, manganese and/or unchlorinated water will be dismissed from consideration as major contributors to condenser corrosion.

Tests and operating results of the individual loops are as follows:

A Loop (K-25 East) and B Loop (K-25 West)

There were no indications of any appreciable changes in heat transfer characteristics during this report period. The corrosion rates are satisfactory.

C Loop (K-27/K-29)

Total pumpage requirements dropped from 60 to 55 million gallons per day. Improvements in heat transfer for "C" loop were probably limited to the K-27 system where the water control valve positions as indicated in K-402-3 closed from 62 to 59 per cent open. K-29 continued to show indications of loss of heat transfer, as the water control valve positions as indicated in K-502-1 opened from 32 to 35 per cent open, with daily peaks as high as 49 per cent open. It may be that the condenser flushing in K-29 is not as effective as in the past.

All the "C" loop corrosion rates are considered to be satisfactory. The latest "C" loop (K-29 return) copper corrosion rate of 0.42 mil per year, after 148 days of Calgon-Coraid treatment, is still much higher than the 0.02 mil per year after 172 days now being obtained on "E" loop with the same water treatment. No definite reason for this difference in corrosion rate is known at present. The "C" loop return copper corrosion rates since changing to Calgon-Coraid treatment are as follows:

Service Days	Corrosion Rate Mils/Year
21	0.30
79	0.83
148	0.42

There were no additional failures of the K-29 "modified" condensers during this report period.

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[5] Ibid.

[6] Technical Division Weekly Report for the Week Ending September 7, 1956, (KLI 3800, Part 11). (Secret)

[7] Technical Division Weekly Report for the Week Ending September 28, 1956, (KLI 3800, Part 14). (Secret)

E Loop (K-31)

The "E" loop supply temperature was raised two degrees to 97° F during this report period. This resulted in the water control valves as indicated in K-602-3 opening from 46 to 55 per cent open. There was no change in the return water temperature and pumpage requirements increased from 75.5 to 76.5 million gallons per day.

There were no condenser failures during this report period.

All corrosion rates are satisfactory, and the short-term copper corrosion rate, after improvements, continues to be amazingly low, with a rate of 0.02 mil per year obtained after 172 service days.

G Loop (K-33)

There were definite gains in heat transfer during this report period, as pumpage requirements dropped from 225 to 220 million gallons per day. The average water control valve position as indicated in K-902-4 closed from 70 to 62 per cent open.

All "G" loop corrosion rates are considered to be good.

There were six process condenser failures during the report period; they are as follows:

1) K-902-2.3 odd - Leakage of 13 pounds per day - one tube plugged and 30 tube sheet leaks repaired.

2) K-902-2.9 odd - Leakage unknown - three tubes plugged - three tube sheet leaks repaired.

3) K-902-8.3 odd - Leakage of 20 pounds per day - 24 tubes plugged - 14 tube sheet leaks repaired.

4) K-902-4.1 even - Leakage of 17 pounds per day. - two tubes plugged - 24 tube sheet leaks repaired.

5) K-902-8.3 even - Leakage of 13 pounds per day - three tubes plugged - 15 tube sheet leaks repaired.

6) K-902-5.3 even - Leakage of 30 pounds per day - 44 tubes plugged - 17 tube sheet leaks repaired.

New Utilities Department Test Loop

The K-892 test loop continued to operate using the high chromate treatment outlined in the previous report. Preliminary data indicate very low copper and steel corrosion rates, but actual corrosion rates obtained to date are somewhat unreliable due to difficulties encountered several times during the report period in determining the actual flow

through the test nipples and the length of service. Alterations have been made to the test nipple installation to allow more reliable observations. Some loss in heat transfer efficiency has been indicated by increased steam pressure, from about 10 psig originally to about 30 psig at the end of the report period, necessary to obtain the same water temperatures. This evidence is supported by the amount of hard scale found in the test nipples.

Monthly Average Water Analyses

Attached are separate monthly average water analyses sheets for each month covered by this report. The hardness and total dissolved solids of the make-up water continued to increase, and this increase is reflected in the recirculating water analyses.

Graphs of Steel and Copper Corrosion Rates

Attached are ten corrosion test curves. These self-explanatory curves cover steel and copper corrosion data for all loops.

Pilot Plant Softening of Clinch River Water

In October an Infilco pilot plant was placed in continuous service, using raw Clinch River water, at the sanitary water plant. The purpose of this operation was to obtain data on the chemical feed requirements for partial softening of Clinch River water and information on continuous operating difficulties, if any. As the attached chart of one month's operation shows, theoretical reduction of hardness with lime was generally obtained. Information was also obtained on softening with lime and soda ash together. As a result of this test, no difficulties are expected in continuous partial softening of Clinch River water.

C. C. Fowlkes

C. C. Fowlkes

Approved: K. M. Jones

K. M. Jones
Process Utilities Department

MONTHLY AVERAGE WATER ANALYSES - SEPTEMBER, 1956

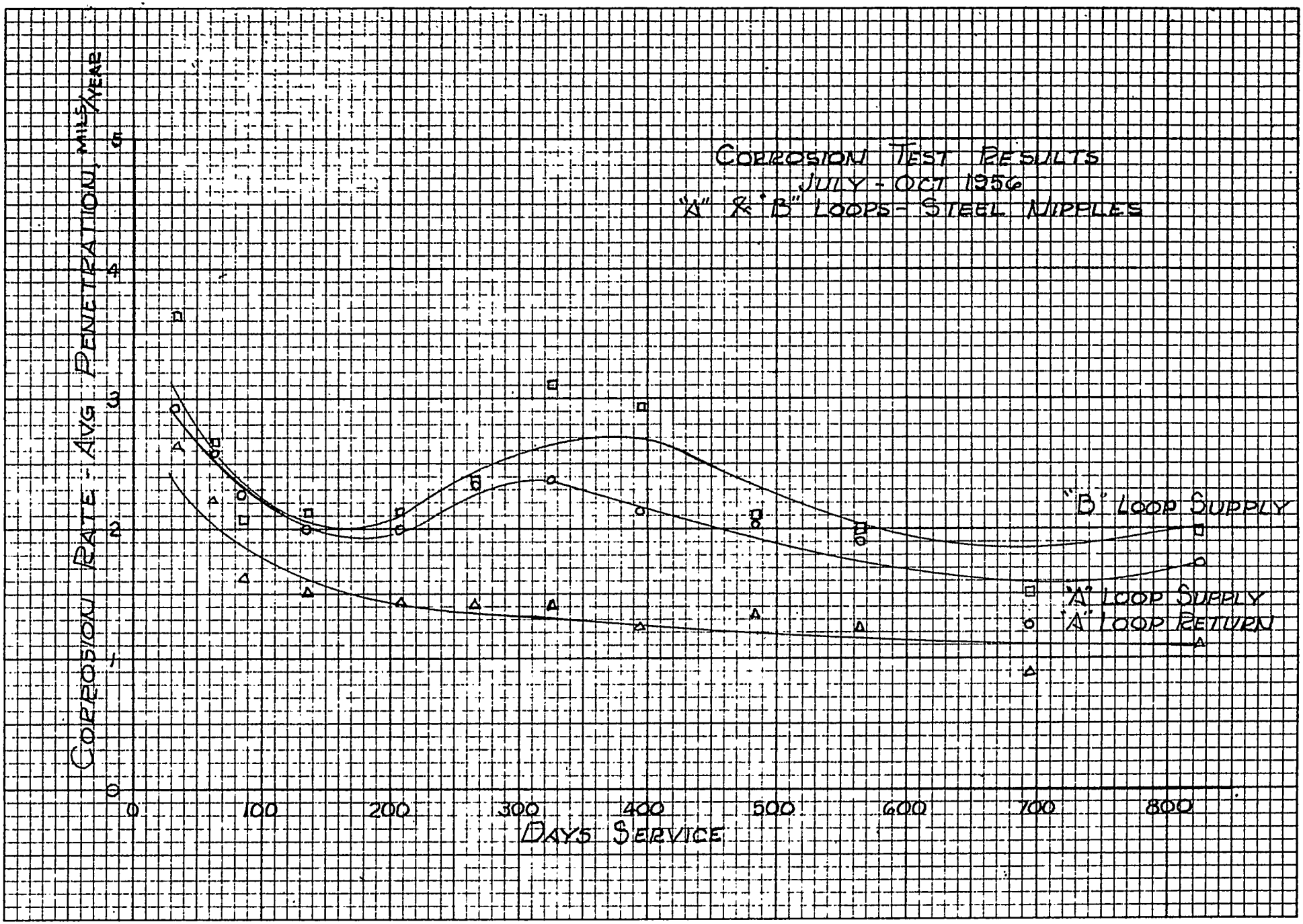
P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP 'A'	'B'	'C'	'E'	'G'
Total Dissolved Solids	247	301	303	651	628	908	937	1203
Meta-Phosphate as $NaPO_3$	0.01	0.43	0.05	8.16	7.97	9.16	7.13	5.37
Ortho-Phosphate as $NaPO_3$	0.65	1.26	0.07	10.89	11.33	9.72	9.33	13.04
Total Hardness as $CaCO_3$	144	150	149	264	249	370	406	491
Calcium as $CaCO_3$	112	113	108	178	183	251	280	344
M-Alkalinity as $CaCO_3$	89	90	85	16	15	11	12	14
Turbidity as SiO_2	9	9	4	21	22	37	39	29
Copper as Cu	0.02	0.02	0.02	0.06	0.06	0.08	0.08	0.04
Total Iron as Fe	0.43	0.50	0.39	0.84	0.86	1.45	1.43	1.33
Manganese as Mn	0.04	0.04	0.04	0.08	0.10	0.18	0.27	0.04
Sulphate as (SO_4)	22	28	31	192	190	282	285	318
Chromates as CrO_4	-	-	-	-	-	-	-	25.1
Suspended Solids	6	8	3	11	11	22	40	28
Zinc as Zn	-	-	-	-	-	1.09	1.26	-
pH	7.92	8.03	7.43	6.76	6.81	6.10	5.91	6.08
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.703		$1.747	$2.037	$2.168
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	3.59		5.41	4.82	5.61

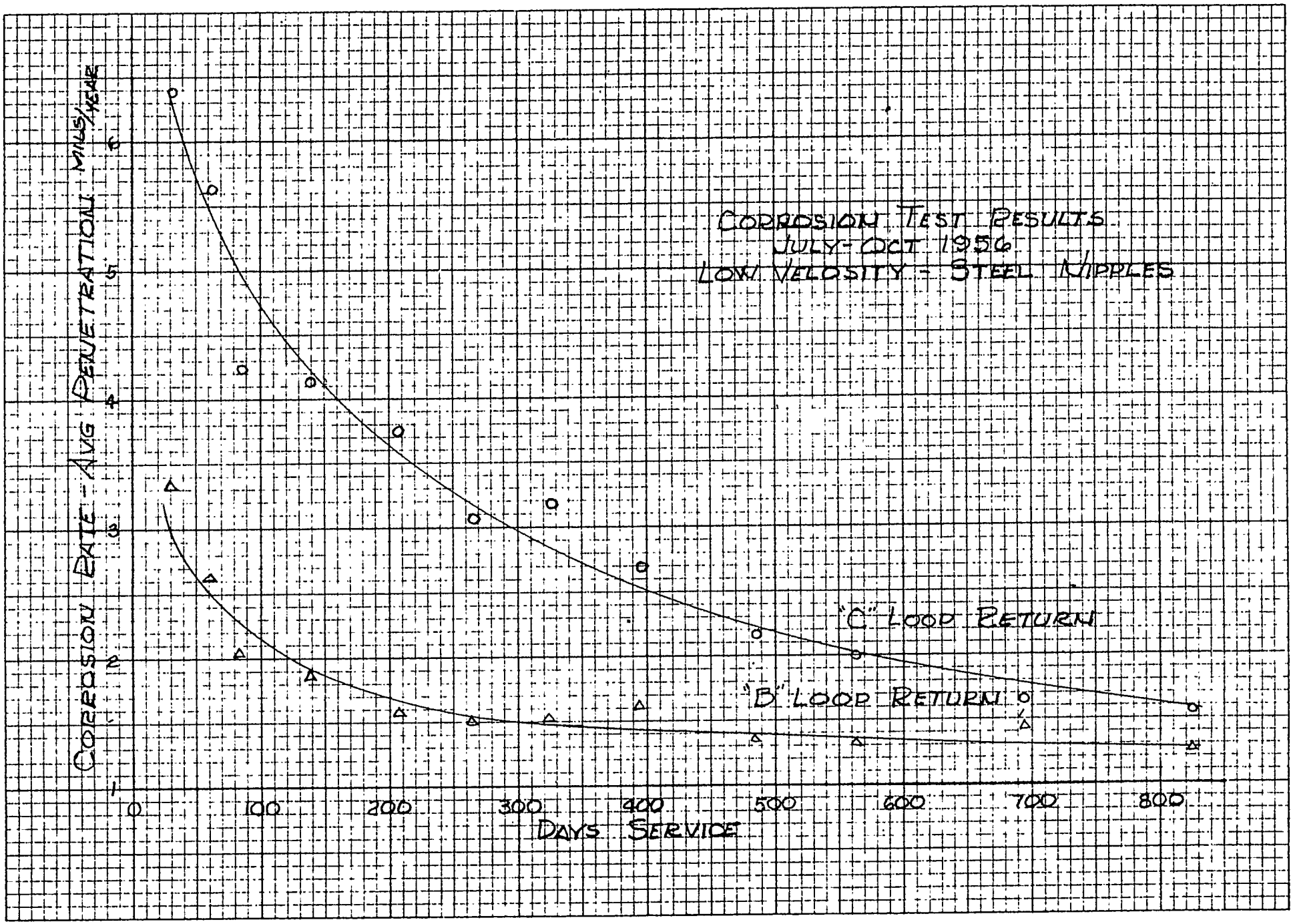
All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

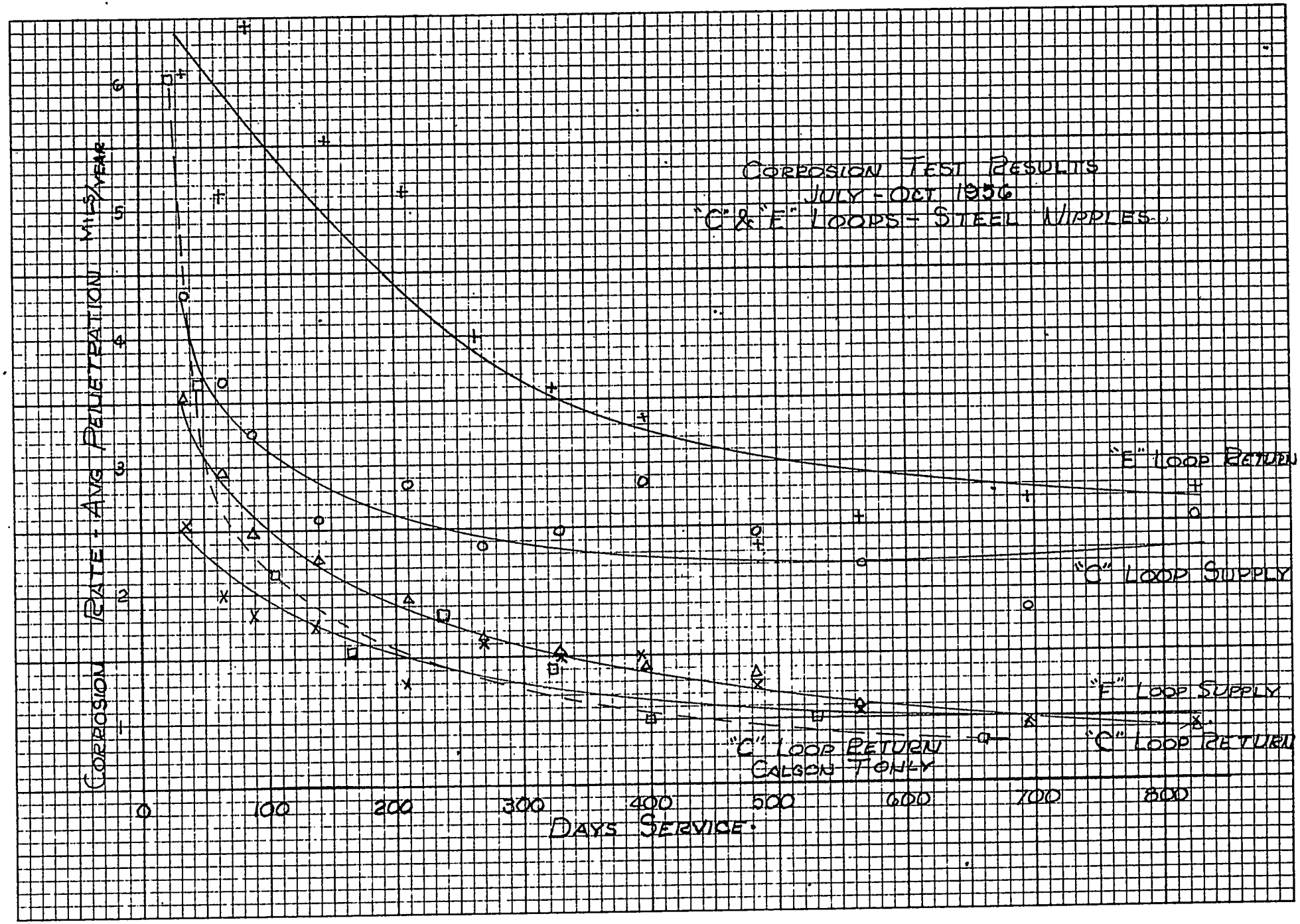
MONTHLY AVERAGE WATER ANALYSES - OCTOBER, 1956

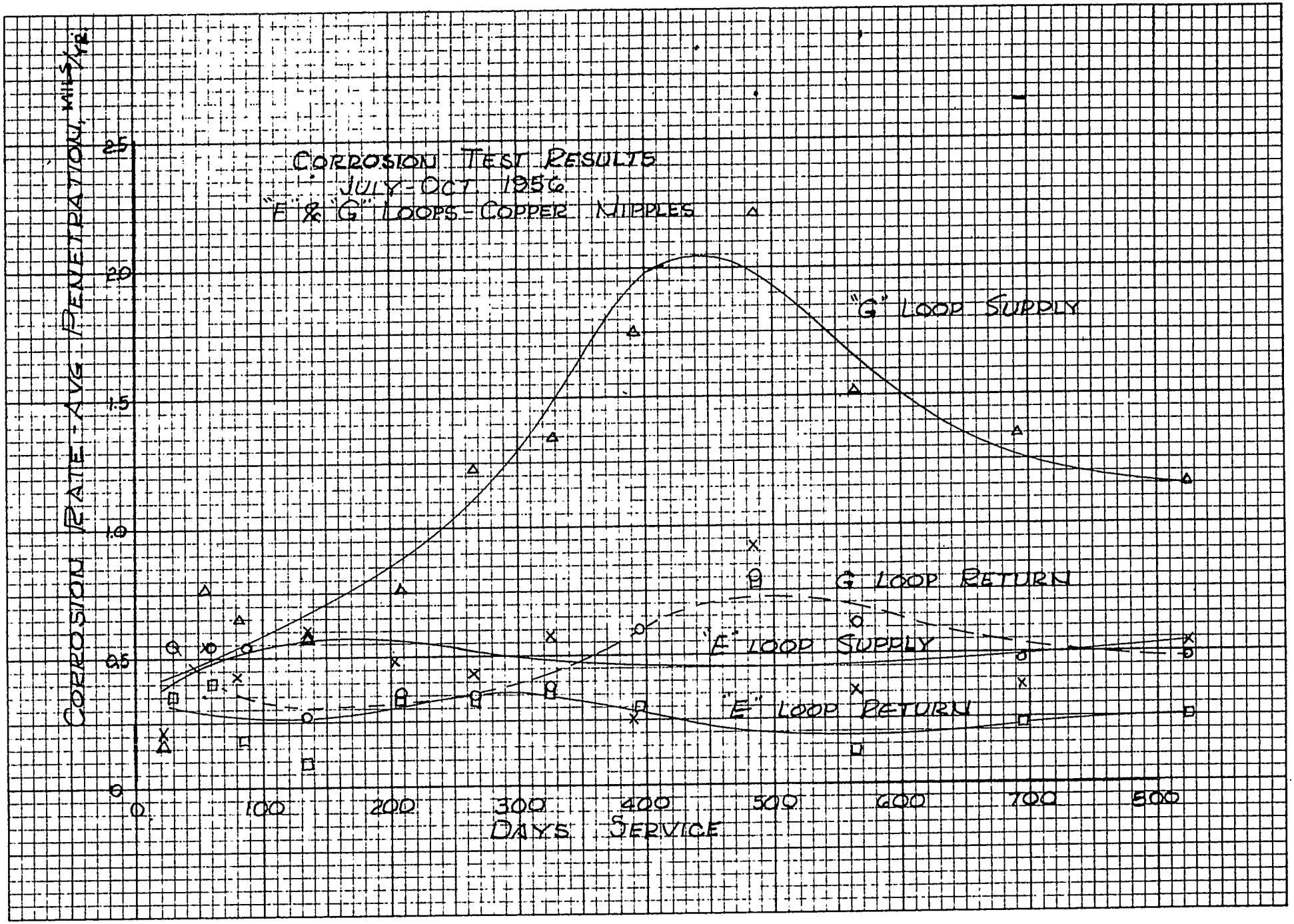
P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP 'A'	'B'	'C'	'E'	'G'
Total Dissolved Solids	292	262	320	678	660	833	909	1180
Meta-Phosphate as $NaPO_3$	0	0.41	0.04	8.61	7.88	9.35	8.71	6.30
Ortho-Phosphate as $NaPO_3$	0.67	1.05	0.10	12.51	13.00	9.74	10.21	12.43
Total Hardness as $CaCO_3$	178	172	182	323	333	392	435	558
Calcium as $CaCO_3$	120	119	129	205	204	259	282	371
M-Alkalinity as $CaCO_3$	88	97	85	18	19	13	13	18
Turbidity as SiO_2	8	8	3	20	20	30	31	35
Copper as Cu	0.13	0.12	0.07	0.13	0.15	0.12	0.11	0.15
Total Iron as Fe	0.82	0.78	1.12	1.02	1.06	1.22	1.32	1.73
Sulphate as (SO_4)	24	24	31	228	231	320	269	343
Chromates as CrO_4	-	-	-	-	-	-	-	22.71
Suspended Solids	6	5	2	10	10	17	17	21
Manganese as Mn	0.04	0.04	0.04	0.10	0.09	0.15	0.29	0.04
Zinc as Zn	-	-	-	-	-	1.18	1.28	-
pH	7.64	7.79	7.26	6.73	6.79	6.11	5.95	6.04
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.708		$1.931	$2.241	$2.163
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	3.57		5.97	5.33	5.62

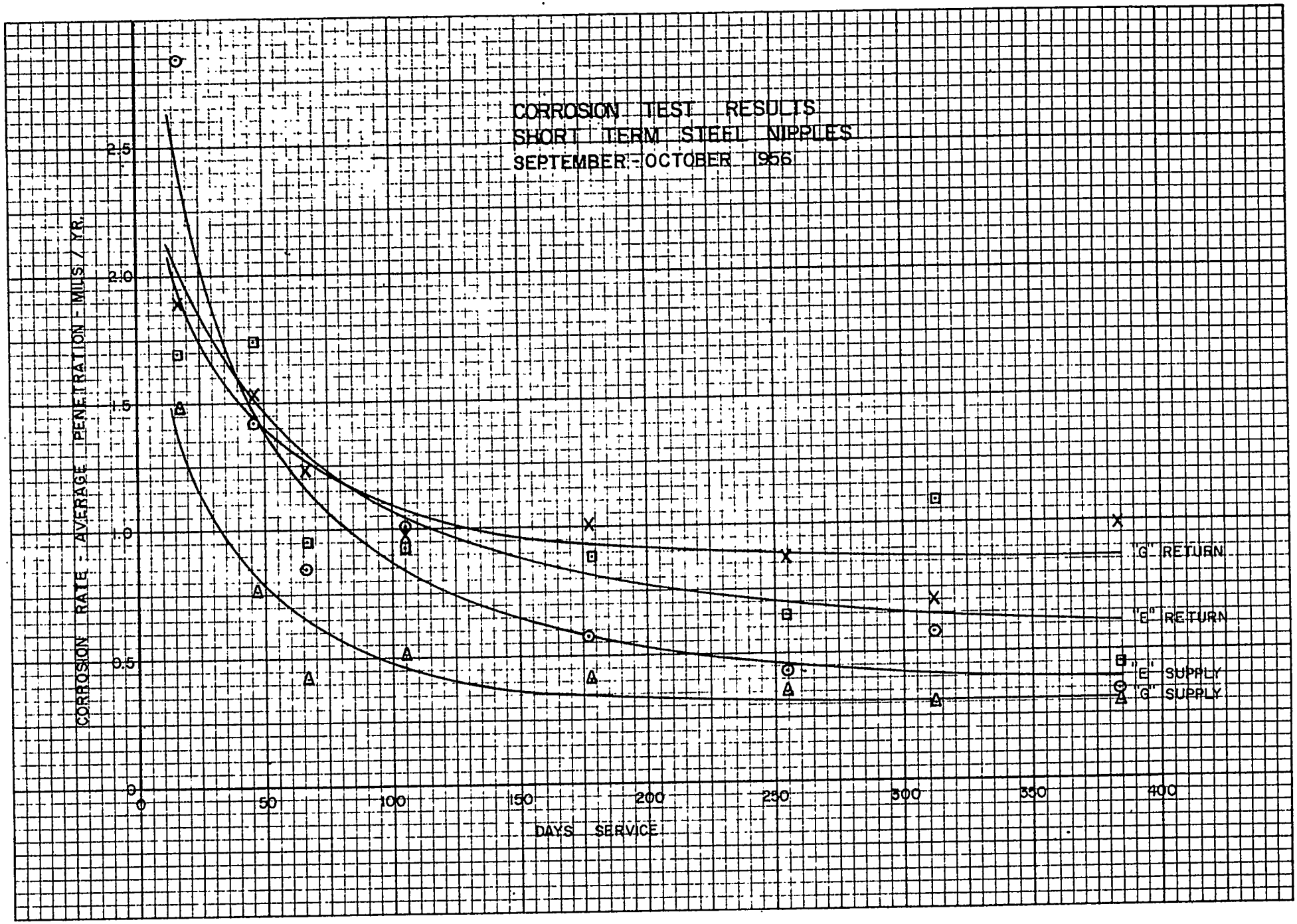
All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

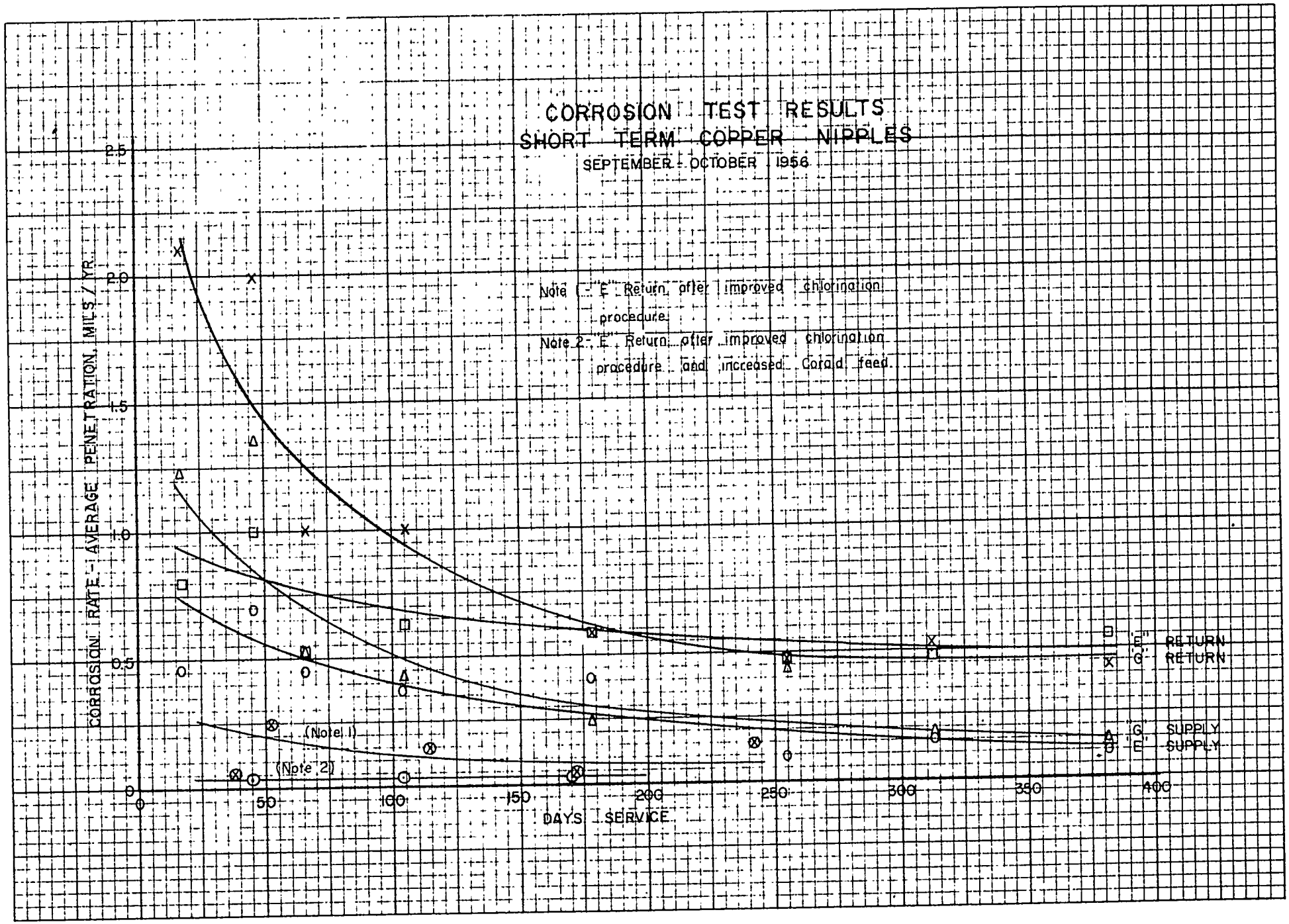


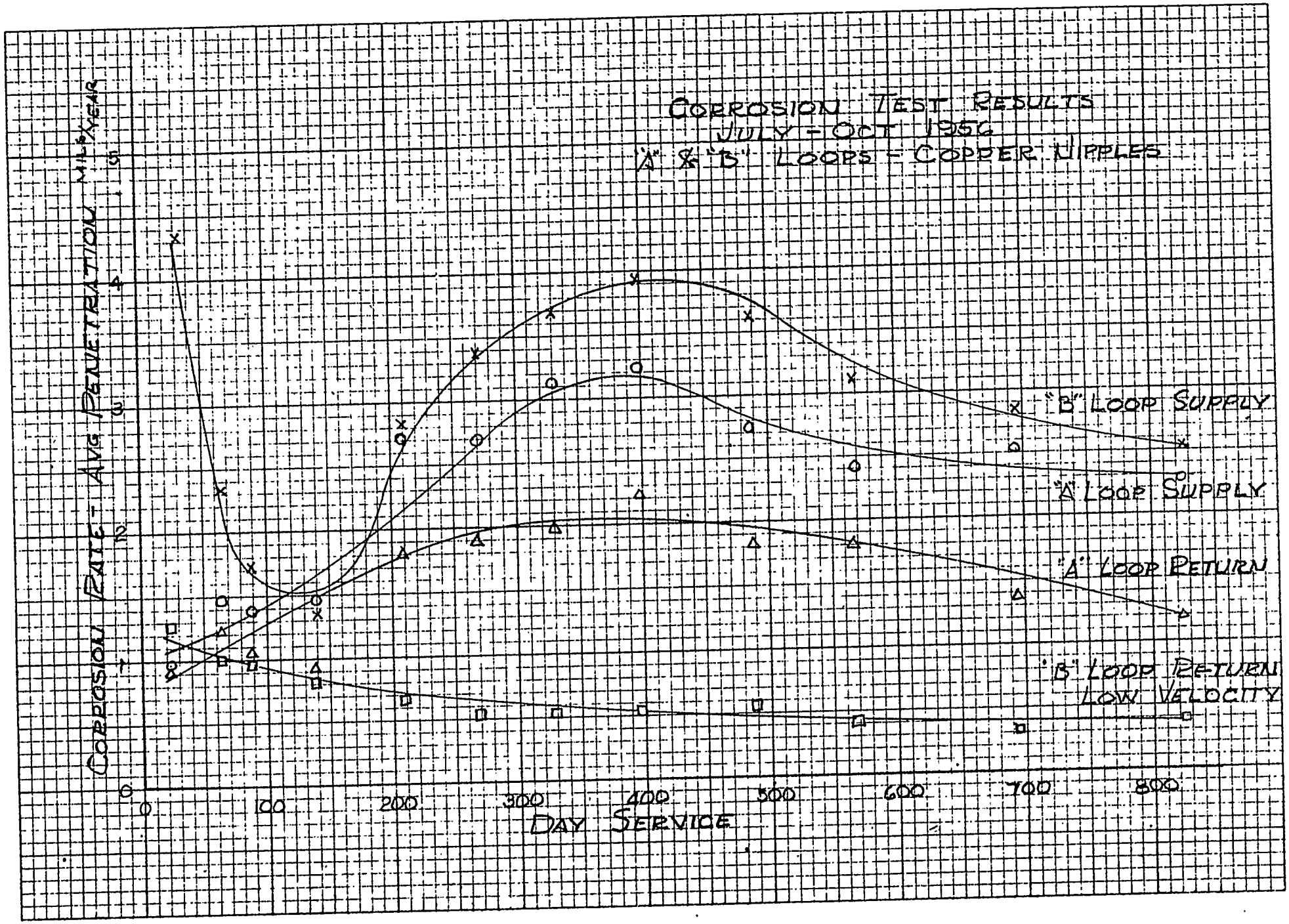


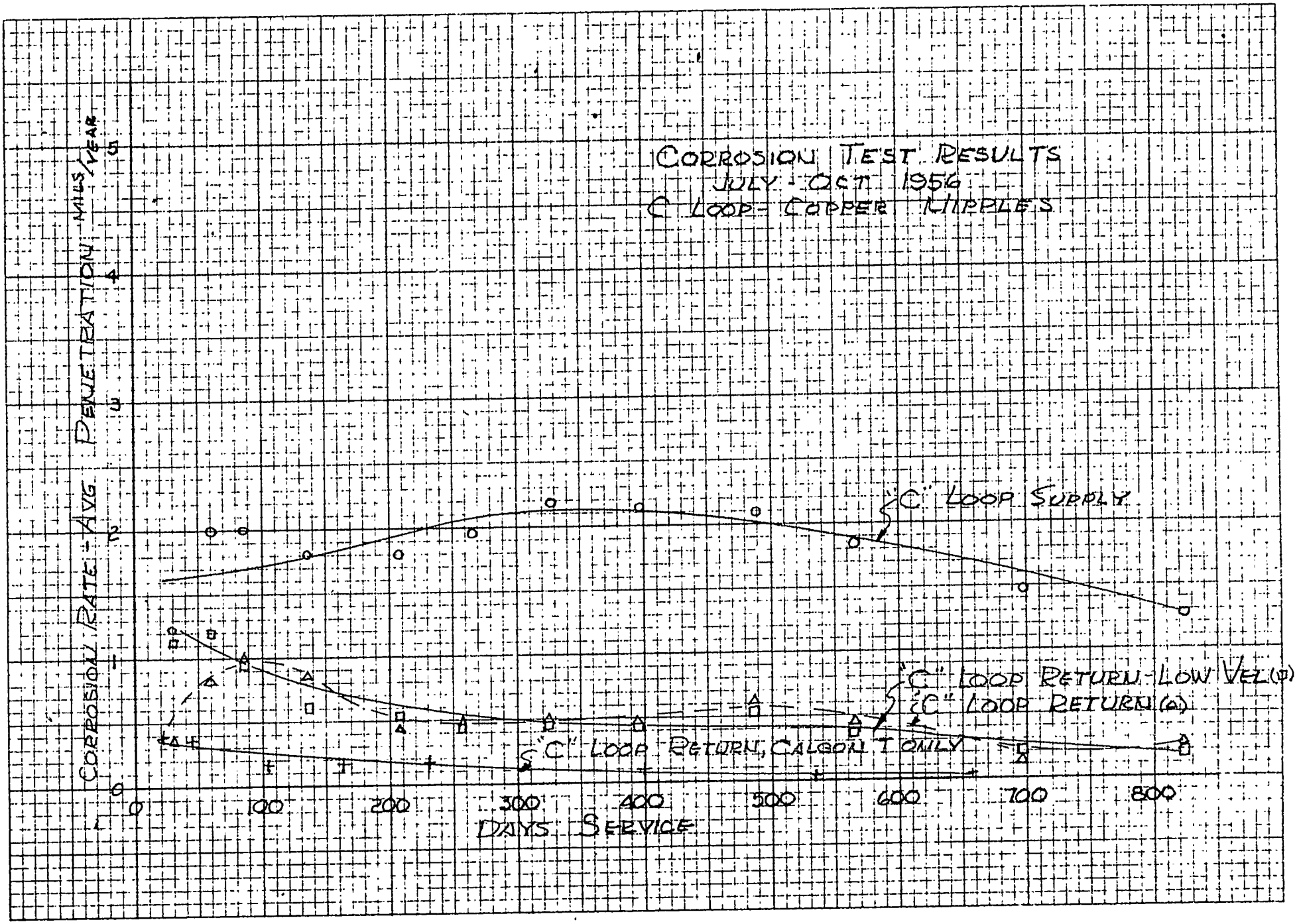


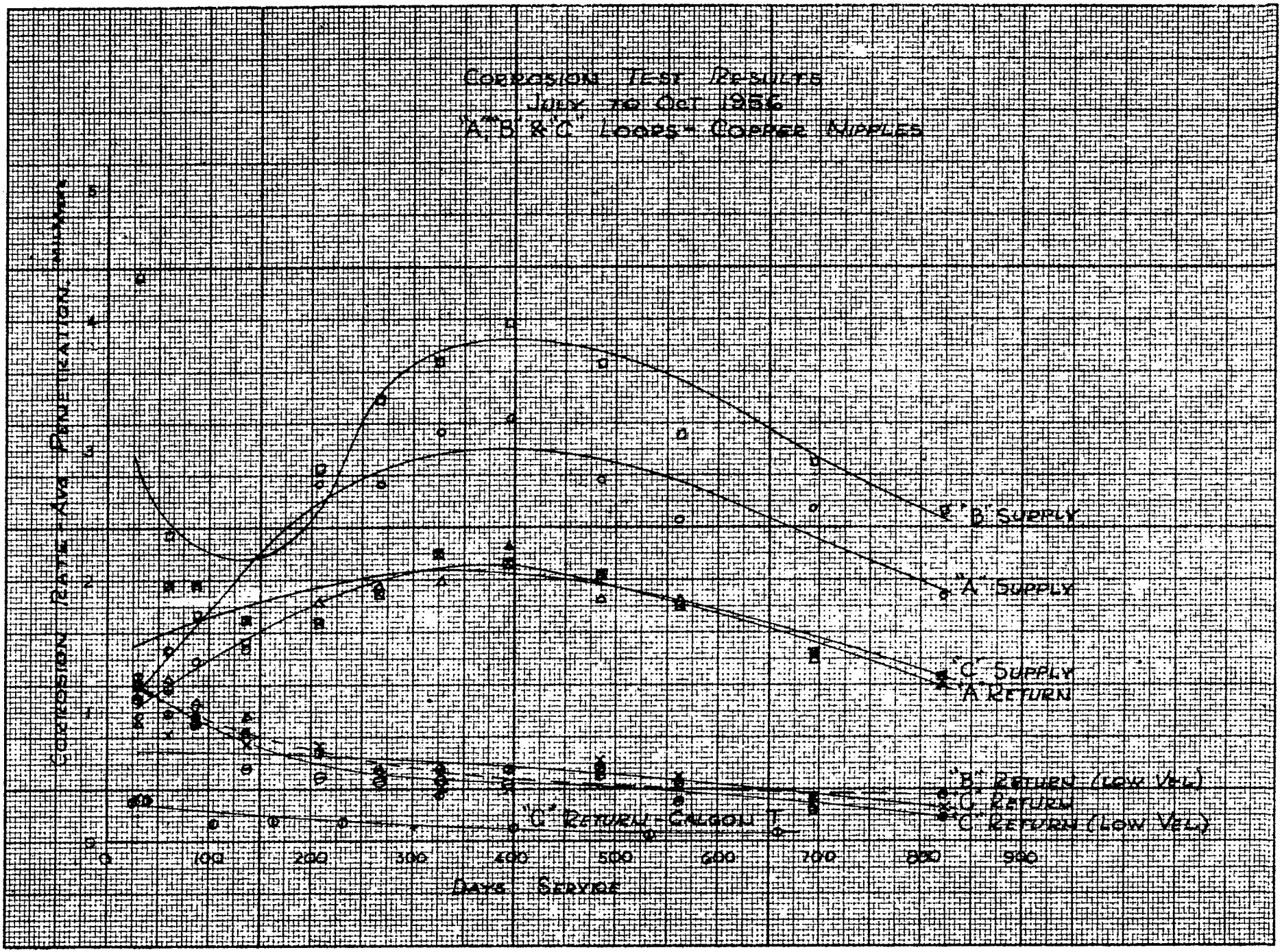


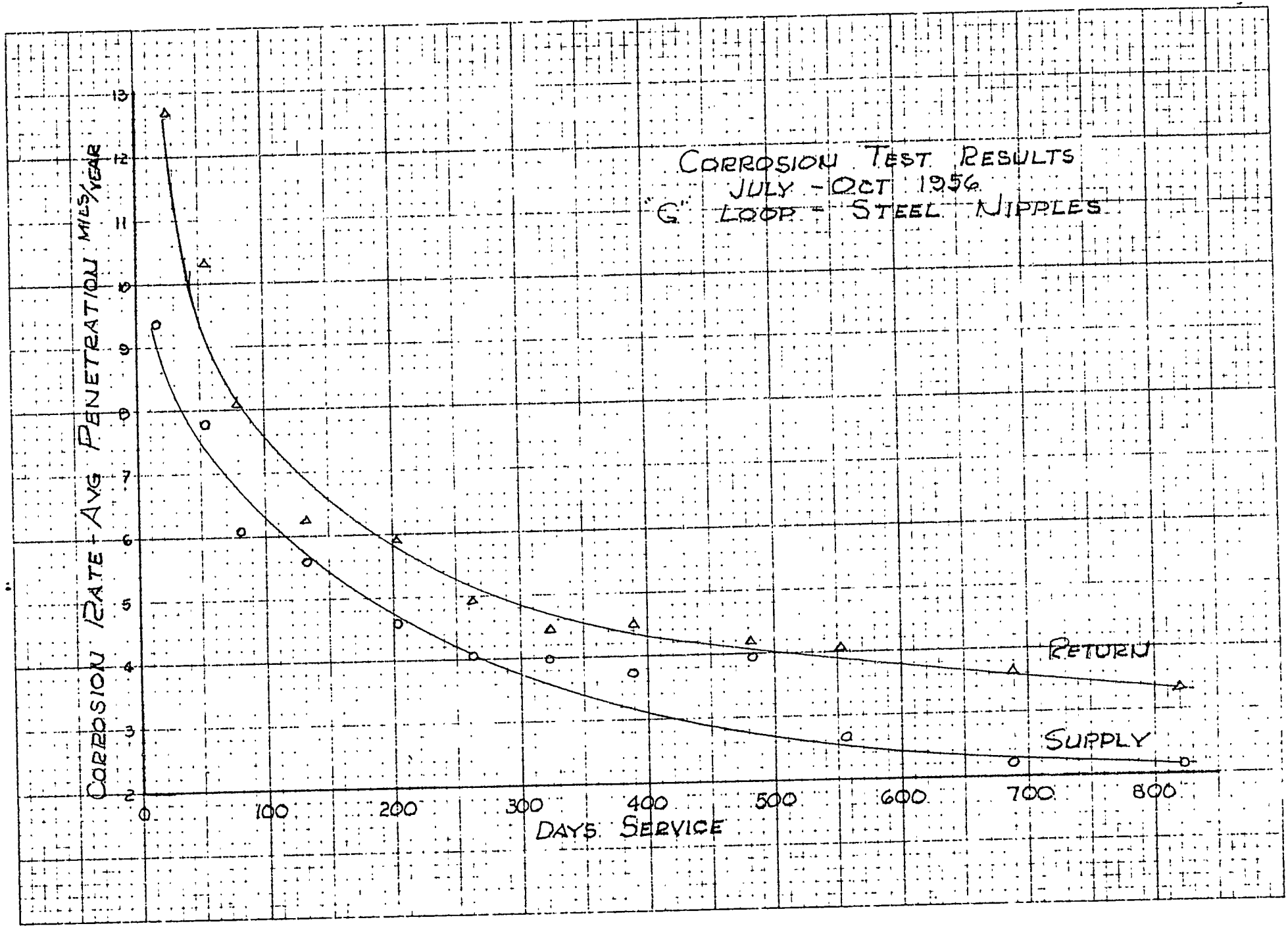


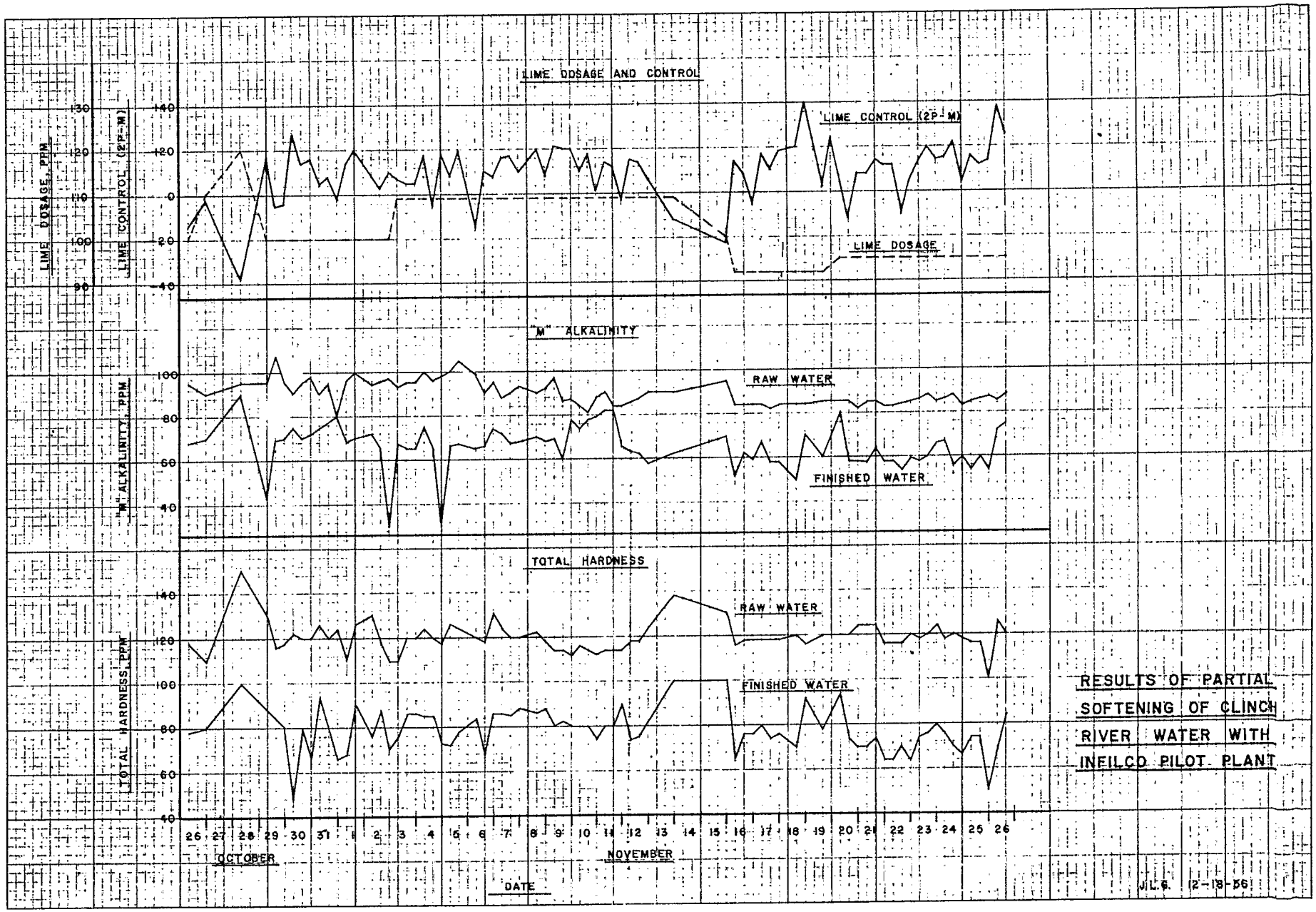












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UNION CARBIDE NUCLEAR COMPANY

Production Division

Utility Operations Department

SUMMARY OF RECIRCULATING WATER TREATMENT TESTS FOR NOVEMBER AND DECEMBER, 1956

C. C. Fowlkes

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SUBJECT Summary of Recirculating Water Treatment Tests for November and December, 1956

KP-570, Part No. 20

In addition to discussions of operating results of all recirculating water systems, this report contains a copper corrosion curve for the K-31 and K-33 recirculating water systems. Also included are two curves related to the Utilities Department high-chromate test loop.

Freon Condenser Corrosion

A tremendous amount of work has been completed during the last one and one-half years, by many people here at ORGDP and elsewhere, regarding the condenser corrosion problem. As it is very difficult to properly evaluate the different water treatments without knowing the real cause or causes of the corrosion, it is hoped that definite conclusions regarding the causes of corrosion can be arrived at in the not-too-distant future.

The most significant developments during this report period are as follows:

1) The major features of the high-chromate (200 ppm) treatment have been previously discussed. From Engineering Development's final report,[1] it is apparent that the condensers should be thoroughly cleaned, if possible, as even high chromate fails to completely penetrate the corrosion products in pits of used, uncleaned tubes.

2) Manganese in the make-up water was discounted as a probable contributor to the copper corrosion problem.[2] No evidence of pitting was found in the K-801-A test loop condenser, operating on unchlorinated Poplar Creek water, with manganese added to maintain an average residual of 0.8 ppm. The test was run for 35 days, and the water was treated with Calgon to give 20 ppm total PO_4.

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[1] Knight, R. G., report to Mr. S. H. Smiley, Test Condenser Evaluation of High Chromate Water Treatment, ORGDP, UCNC, November 20, 1956, (KLD-402).

[2] Technical Division Weekly Report for the Week Ending November 2, 1956, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, November 5, 1956, (KLI 3800, Part 19). (Secret)

3) The K-31 test condenser, operated with no heat load, continues to show tubercles and large shallow pits.[3] Of fourteen tubes from this condenser, twelve have had tubercles and shallow pits.

4) The test condenser in K-1401, using "A" loop water, showed no pitting after 277 days of service, when probed with "Multitest" instrument.[4] The tubes were so heavily scaled, however, that the probe could not be pushed more than halfway through the tubes. The heavy scaling apparently occurred during the two-week period prior to shutdown, as the steam pressure required to maintain an outlet water temperature of 155° F increased from 20 to 50 psig during this period. Examination of the data on "A" loop water composition and chemical treatment during this period failed to indicate any abnormal condition which might have caused the sudden scale build-up.

5) Conflicting evidence was obtained from examination of eight tubes from the K-31 test condenser, with heat load.[5] A total of eight tubes removed from test condenser 6D3-402 on October 17, 1956, were examined after exposure periods ranging from 78 to 297 days. The results of the examinations were anomalous in that a standard copper tube with 78 days' service and de-greased standard copper tubes with 78 and 112 days' service were found to be pitted, while no pitting was found in a standard copper tube with 112 days' service or a de-greased standard tube with 227 days' service.

Of six standard and de-greased standard tubes installed in this condenser since June, 1956, four have shown significant pitting, while, of twelve standard and de-greased standard tubes installed prior to this date, only three have been pitted, and a total of only five pits were found in these three tubes. A detailed investigation of "E" loop water composition and water treatment practice, as well as the test condenser operating conditions, showed that numerous changes occurred during the latter part of May through the first of June, any one of which may have contributed to the recent pitting now being encountered. During the period from April 22, 1956 through June 10, 1956, there were the following changes: the Coraid feed was increased in rate; the make-up was changed from K-892 to K-801-A; the recirculating water increased in

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[3] Technical Division Weekly Report for the Week Ending November 16, 1956, (KLI 3800, Part 21). (Secret)

[4] Technical Division Weekly Report for the Week Ending December 7, 1956, (KLI 3800, Part 24). (Secret)

[5] Technical Division Weekly Report for the Week Ending December 21, 1956, (KLI 3800, Part 26). (Secret)

total hardness, chlorides, sulphates, turbidity and total solids; and Poplar Creek increased in mercury concentration. The large increase in the mercury concentration of Poplar Creek coupled with changing "E" loop make-up back to the untreated K-801-A source could explain the recent pitting. For example, seventeen samples during April and May averaged only 14 parts per billion of mercury, the range being from 0 to 72 ppb., but the first three samples taken in June (1st, 5th, and 8th) showed concentrations of 1158, 1360 and 1158 ppb. It may well be that the tubes with longer service had enough deposition for some protection from the unusually high mercury concentration, while the more recently installed tubes, with clean surfaces, quickly picked up mercury and pitted.

Tests and operating results of the individual loops are as follows:

A Loop (K-25 East) and B Loop (K-25 West)

Pumpage requirements gave no indications of any appreciable changes in heat transfer characteristics during this report period. The water control valves in K-309-2 opened from 45 to 49 per cent open, while those in K-304-4 closed from 34 to 22 per cent open.

C Loop (K-27/K-29)

Total pumpage requirements increased slightly, from 55 to 56 million gallons per day. K-29 continued to show indications of loss of heat transfer, as the average water control valve position in K-502-1 cells opened from 35 to 41 per cent open, with daily peaks as high as 57 per cent open. A small increase in the K-27 power load probably accounted for the average opening of the K-402-3 water control valves, from 59 to 61.5 per cent open.

The original, unmodified condenser from K-502-1.6 was removed for cleaning early in December, 1956. No leakage was suspected; the condenser was removed solely because of poor heat transfer. The condenser was cleaned by the latest acid-cleaning procedure and no leaking tubes were found, following cleaning. No tubes were removed for examination and present plans are to reinstall this condenser in K-502-1.4 position in January, 1957.

E Loop (K-31)

There were several indications of loss of heat transfer characteristics during this report period, as pumpage increased from 76.5 to 79 million gallons per day, return water temperature dropped from 146.5 to 144.5° F, and the average water control valve position as measured in K-602-3 opened from 55 to 59 per cent open.

Omitted from the last report was the discussion of condenser no. 219008.[6]

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[6]Ellis, J. M., letter to Mr. K. M. Jones, Summary of K-31 F-114 Condenser Failures, March 6, 1957.

This condenser had no known leaks and was removed on October 15, 1956 for the purpose of obtaining water flow and heat exchange data. This data was needed for the evaluation of the recirculating water system and estimating the necessary up-rating required for the "A"-Line cooling program. The condenser was acid-cleaned (procedure no. 1) and dried. A 50-psig air test revealed a total of 51 leaking tubes. Apparently, many of the K-31 condensers will not stand acid-cleaning with the present procedure without developing an excessive number of leaks, but this is not unexpected, as the first K-31 condenser (K-602-3.5) removed from service for examination on June 25, 1955, after discovering the K-33 failures, showed 19 tube leaks with hydrostatic test[7] and 40 additional tube leaks after acid-cleaning with cleaning procedure no. 2.

There were no condenser failures during this report period.

G Loop (K-33)

As with K-31, there were several indications of loss of heat transfer characteristics during this report period. The pumpage increased from 220 to 242 million gallons per day, the return water temperature dropped from 151° to 148° F, and the water control valves as indicated in K-902-4 opened from 62 to 66 per cent (average) open with daily peaks as high as 80 per cent open. Some of the indicated loss in heat transfer was due to the addition of nitrogen to the freon in a total of eleven cells in units 5 and 7 during this period. This was done to increase the water velocity through the condensers and naturally contributes to the drop in return water temperature and increase in pumpage.

There were two condenser failures during the report period; they are as follows:

1) K-902-4.2 even - Leakage of 25 lb/day - 4 tubes plugged - 18 tube sheet leaks repaired.

2) K-902-7.4 even - Leakage of 7 lb/day - 1 tube plugged - 3 tube sheet leaks repaired.

Utilities Department Test Loop at K-892

The high-chromate test was completed, and, as the attached corrosion curve indicates, the results were very good from a corrosion standpoint.

Also attached is a curve showing that the log mean temperature difference of steam to water had leveled off after 15 days--indicating no appreciable deposition after that time, but a loss of heat transfer capacity of about 50 per cent is indicated due to the nature of the scale deposited. Some loss was expected since the concentration ratio was extremely high for this test (10:1).

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[7] Ibid.

Monthly Average Water Analyses

Attached are separate monthly average water analyses sheets for the months of November and December, 1956.

Starting with the month of December, 1956, the copper concentration is reported both by total amount and by the soluble portion. All previously reported copper concentrations were the amounts in solution only.

The total dissolved solids of all recirculating water loops decreased each month.

Graph of Copper Corrosion Rates

Attached is a copper corrosion test curve for "E" and "G" loops, giving the latest results as determined by copper test nipples. As the graph shows, good rates are being obtained on both systems.

for C. C. Bowlkes

Approved L. L. Anthony
Process Utilities Department

MONTHLY AVERAGE WATER ANALYSES - NOVEMBER, 1956

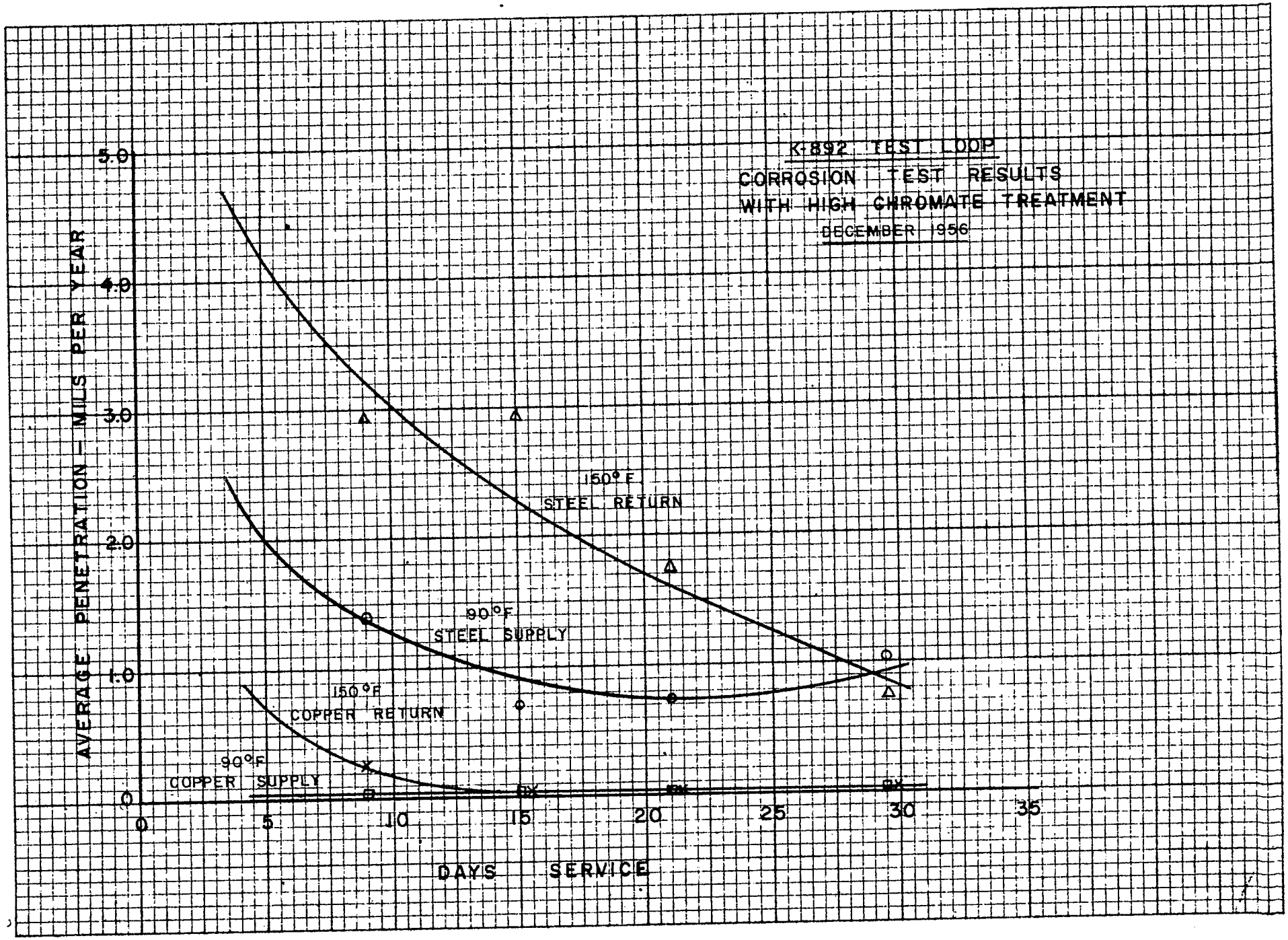
P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	275	280	300	606	602	781	837	999
Meta-Phosphate as $NaPO_3$	0.32	0.63	0.26	7.48	6.95	8.98	7.46	5.27
Ortho-Phosphate as $NaPO_3$	0.94	0.96	0.84	9.78	10.04	7.33	8.40	11.16
Total Hardness as $CaCO_3$	162	166	165	302	304	386	435	478
Calcium as $CaCO_3$	118	123	114	194	184	251	287	324
M-Alkalinity as $CaCO_3$	97	99	95	17	16	9	10	13
Turbidity as SiO_2	13.4	12.5	4.8	21	22	37	30	27
Copper as Cu	0.10	0.09	0.09	0.08	0.09	0.14	0.14	0.18
Manganese as Mn	0.08	0.06	0.07	0.18	0.18	0.36	0.43	0.06
Total Iron as Fe	0.38	0.88	0.50	0.50	0.48	0.47	0.53	0.74
Sulphate as (SO_4)	42	47	56	178	206	265	286	299
Chromates as CrO_4	-	-	-	-	-	-	-	20.81
Suspended Solids	9	24	4	10	10	24	15	16
Zinc as Zn	-	-	-	-	-	1.26	1.36	-
pH	7.43	7.50	7.28	6.76	6.78	6.07	5.92	6.04
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.772		$1.934	$2.188	$1.930
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	3.89		6.17	5.32	5.46

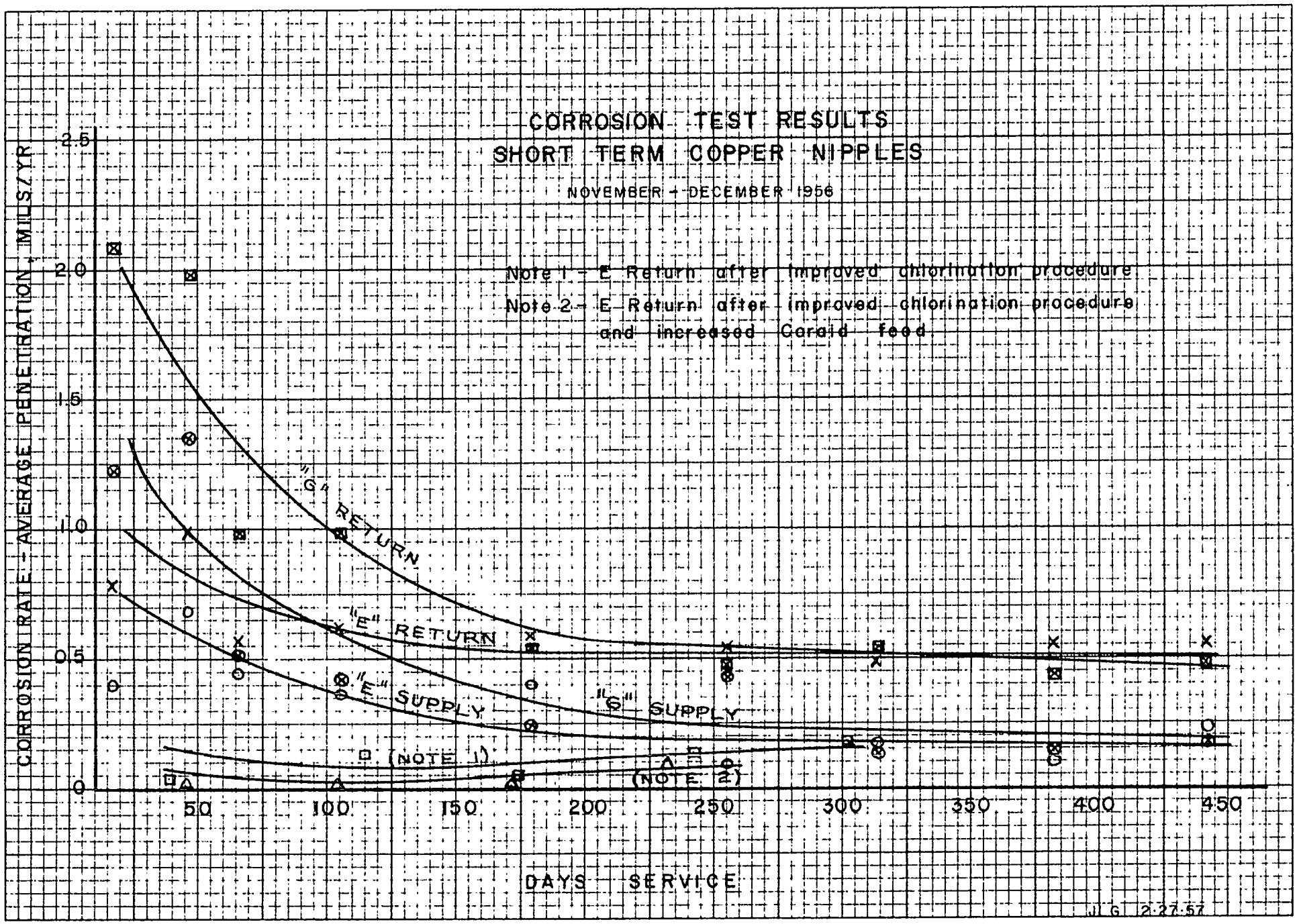
All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

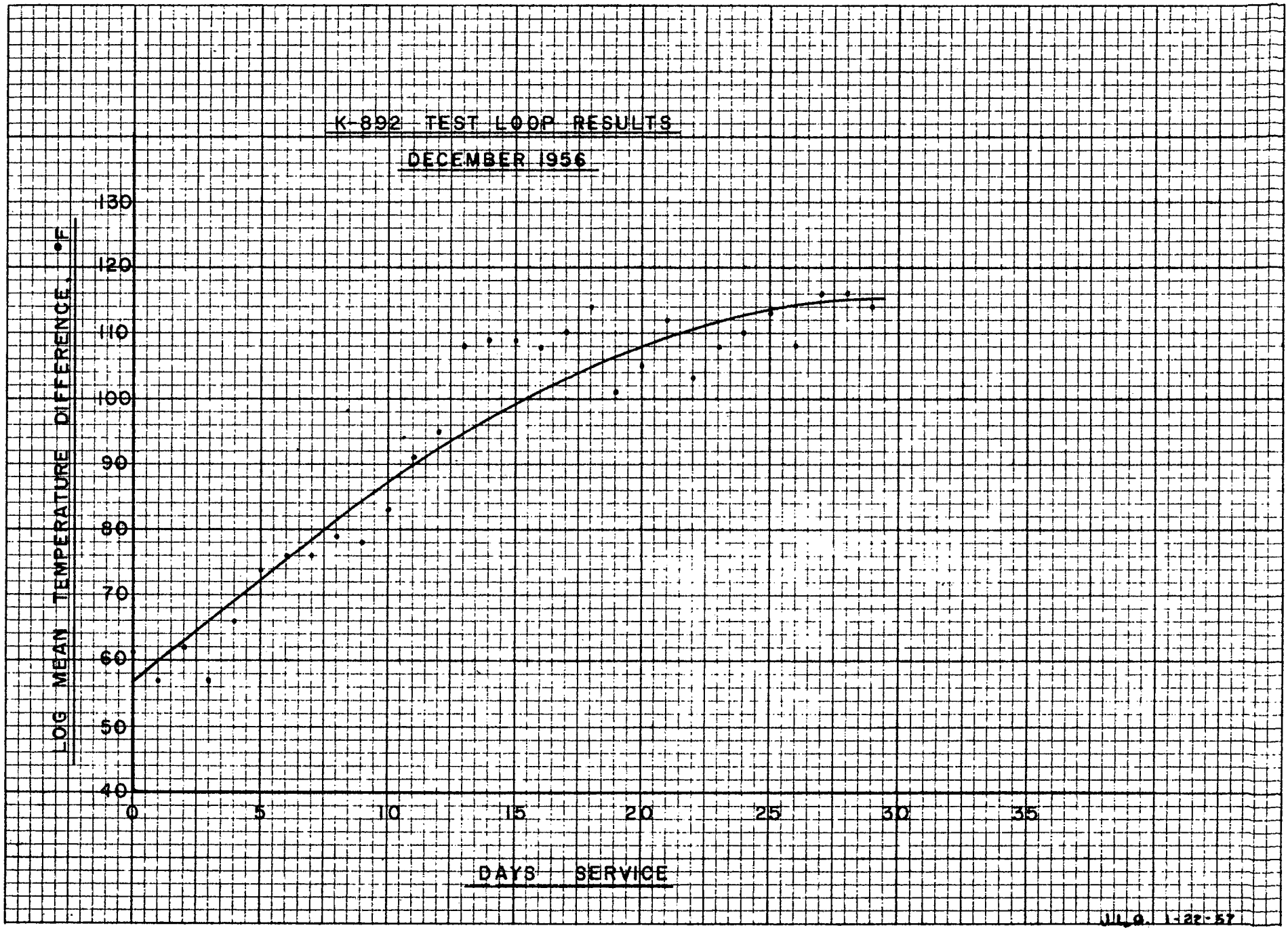
MONTHLY WATER ANALYSES - DECEMBER, 1956

P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP 'A'	'B'	'C'	'E'	'G'
Total Dissolved Solids	243	252	267	551	563	663	745	897
Meta-Phosphate as $NaPO_3$	0.47	1.21	0.18	7.20	7.49	8.53	6.42	6.11
Ortho-Phosphate as $NaPO_3$	0.78	1.39	0.11	10.15	10.45	6.45	7.39	11.24
Total Hardness as $CaCO_3$	153	153	147	281	290	322	357	432
Calcium as $CaCO_3$	101	101	85	191	180	223	225	278
M-Alkalinity as $CaCO_3$	80	86	70	16	14	8	9	14
Turbidity as SiO_2	44.9	10.4	5.4	22	22	29	30	12
Copper as Cu - Soluble	0.06	0.06	0.06	0.07	0.07	0.08	0.07	0.12
" " " - Total	0.07	0.07	0.06	0.07	0.12	0.11	0.12	0.35
Total Iron as Fe	0.37	0.42	0.34	0.51	0.52	0.73	0.52	1.13
Manganese as Mn	0.05	0.05	0.05	0.09	0.09	0.17	0.30	0.06
Sulphate as (SO_4)	33	38	46	183	185	254	264	310
Chromates as CrO_4	-	-	-	-	-	-	-	19.93
Suspended Solids	4	7	1	10	10	15	17	11
Zinc as Zn	-	-	-	-	-	1.30	1.35	-
pH	7.33	7.19	7.09	6.73	6.75	6.05	5.89	6.05
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.837		$1.882	$2.116	$2.088
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	4.42		6.02	5.16	5.67

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.







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Date of Issue: June 6, 1957

Report Number: KP-570, Part No. 21

UNION CARBIDE NUCLEAR COMPANY

Production Division

Utility Operations Department

SUMMARY OF RECIRCULATING WATER TREATMENT TESTS FOR JANUARY AND FEBRUARY, 1957

C. C. Fowlkes

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Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, Operating Contractor for the U.S. Atomic Energy Commission.

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(INSERT NAME) COMPANY CARBIDE AND CARBON CHEMICALS COMPANY LOCATION Post Office Box P OAK RIDGE, TENN.

TO Mr. H. G. P. Snyder
LOCATION K-303-7

DATE June 6, 1957

ANSWERING LETTER DATE

ATTENTION
COPY TO Attached Distribution

SUBJECT Summary of Recirculating Water Treatment Tests for January and February, 1957

KP-570, Part No. 21

In addition to discussions of operating results of all recirculating water systems, this report contains both "long-term" corrosion curves for all recirculating water systems and "short-term" corrosion curves for the K-31 and K-33 recirculating water systems.

Freon Condenser Corrosion

The most significant developments during this report period are as follows:

1) The reintroduction of the possibility that mercury may be the primary or principal cause of freon condenser corrosion. Attention to mercury was drawn by Mr. J. P. Kleber's letter[1] in January in which he stated that they were shocked to find that we still had, at times, very high (over 1 part per million) concentrations of mercury in the make-up water. Mr. Kleber was apparently under the mistaken impression that steps had been taken to eliminate the source of mercury contamination. Actually, following assurance by our technical staffs that it was doubtful whether mercury was contributing to our copper corrosion, we have not attempted to further investigate this possibility. However, in view of the fact that more likely causes have not been discovered, perhaps a more complete investigation of mercury contamination might be in order.

2) Metallurgical examination revealed no pits in a standard copper tube with 115 days' service or in arsenical annealed and standard copper degreased tubes with 277 days' service in test condenser 6D3-420 using "A" loop supply cooling water in building K-1401.[2] This condenser has a supply temperature of 95° F and a return water temperature of 155° F. Surface attack was

---

[1] Letter from Mr. J. P. Kleber, Calgon Company, to Mr. K. M. Jones dated January 29, 1957.

[2] Technical Division Weekly Report for the Week Ending January 5, 1957, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, January 8, 1957, (KLI 3800, Part 28). (Secret)

generally slight on all of the tubes with a few small patches of moderate attack. The scale was in two layers, each about 0.015 inch thick, and consisted of a gray, powdery surface scale over a brown, brittle, glossy subscale which was difficult to dissolve in hydrochloric acid. Nine tubes with exposure periods of 72 to 277 days in this test condenser have now been examined with no evidence of pitting or excessive surface attack being noted.

3) A standard copper and a degreased standard copper tube were examined after 34 days' exposure in test condenser 6D3-422 in the K-801-A test loop.[3] The water treatment during this period consisted of a simulated Nalco-N-33 treatment (20 ppm phosphate, 4 ppm ferrocyanide, 6.1 pH) using sanitary water make-up with a loop residence time of about 6 days. This condenser has a supply temperature of 100° F and a return water temperature of 135° F. No pits were found in the tubes, and the surface attack was slight--covering about one third of the tube surface. The tubes had a dark brown film of subscale under a soft, powdery, brown scale about 0.015 inch thick.

Tests and operating results of the individual loops are as follows:

A Loop (K-25 East) and B Loop (K-25 West)

During this report period, there were no indications of any appreciable changes in heat transfer characteristics as would be reflected by pumpage requirements or water control valve positions.

C Loop (K-27/K-29)

Total pumpage requirements increased slightly, from 56 to 57 million gallons per day. K-29 continued to show indications of loss of heat transfer, as the average water control valve position in K-502-1 cells opened from 41 to 45 per cent open. There was no appreciable change in the K-27 water control valves as indicated by the K-402-3 cells.

The condenser from K-502-1.4 was removed on January 29 to repair a tube sheet leak. This condenser was acid cleaned for 45 minutes, with no tube leaks developing.

E Loop (K-31)

There is conflicting evidence regarding heat transfer changes, as the water control valves in K-602-3 closed from 59 to 55 per cent open, and the total pumpage increased from 79 to 83 million gallons per day. At present, it is believed that pump flow figures are erroneously high and that slight improvements in heat transfer were made.

---

[3] Technical Division Weekly Report for the Week Ending January 11, 1957, (KLI-3800, Part 29). (Secret)

There were no condenser failures during this report period.

G Loop (K-33)

There were definite improvements in heat transfer during this report period, as the pumpage requirements dropped from 242 to 227 million gallons per day and the water control valves as indicated in K-902-4 closed from 66 to 65 per cent open with a 1° F rise in return water temperature to 149° F.

Six leaking condensers were repaired during the report period; they are as follows:

1) K-902-1.8 even - January 10, 1957; leakage of 5 lb./day; 8 tube sheet leaks.

2) K-902-3.6 even - January 14, 1957; leakage of 600 lb./day; 1 tube leak.

3) K-902-1.4 odd - January 15, 1957; leakage of 30 lb./day; 2 tube leaks.

4) K-902-4.1 even - February 4, 1957; 14 tube leaks, 8 tube sheet leaks.

5) K-902-1.1 odd - February 21, 1957; 5 tube sheet leaks.

6) K-902-1.1 odd - February 26, 1957; 1 tube leak.

Graphs of Steel and Copper Corrosion Rates

Attached are ten corrosion test curves. These self-explanatory curves cover steel and copper corrosion data for all loops.

Monthly Average Water Analyses

Attached are separate monthly average water analyses sheets for each month covered by this report. Large reductions in the dissolved solids of the make-up water is reflected in the recirculating water analyses.

C. C. Fowlkes

C. C. Fowlkes

Approved _____

L. L. Anthony
Process Utilities Department

MONTHLY AVERAGE WATER ANALYSES - JANUARY, 1957

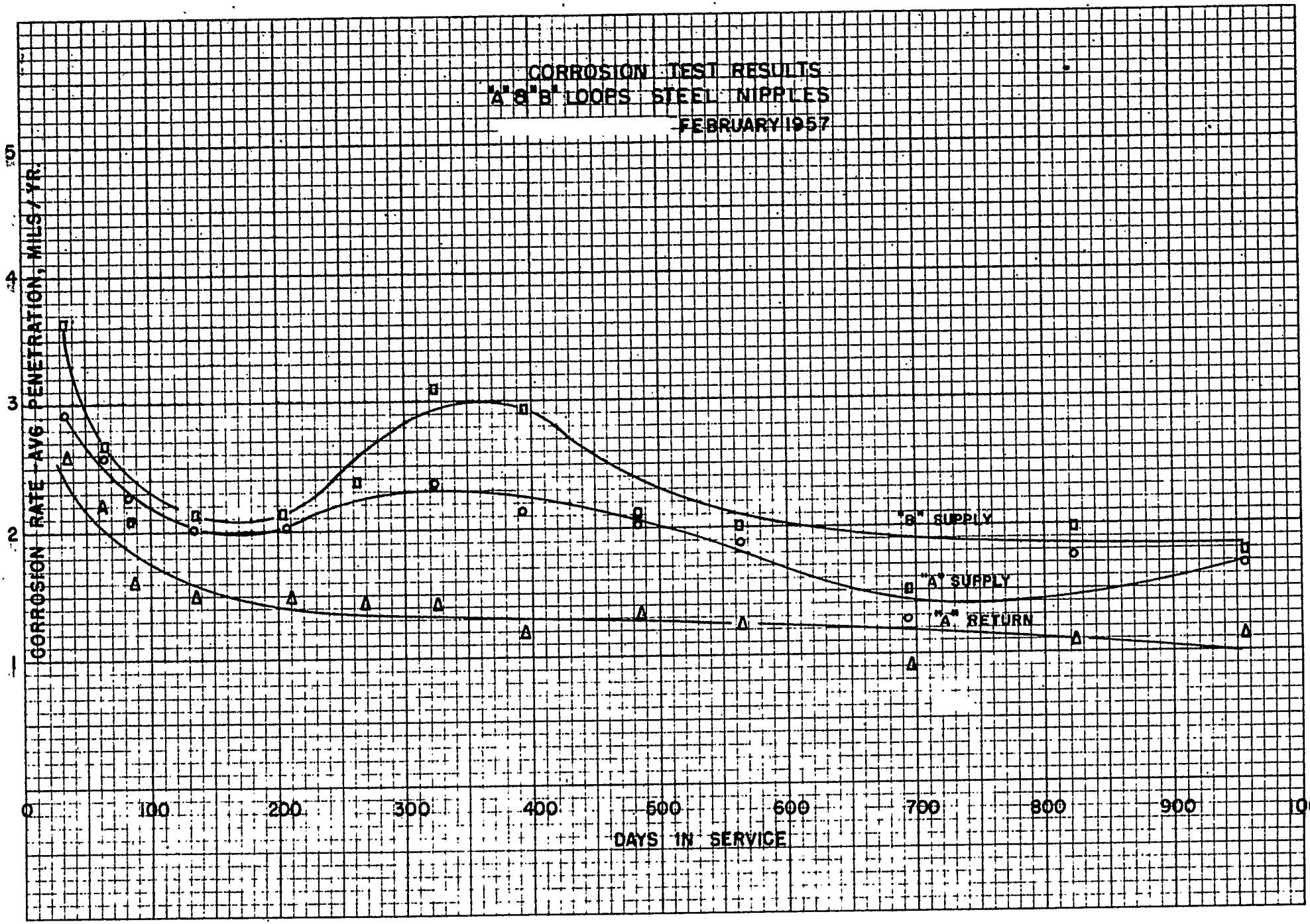
P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	128	130	124	316	325	427	472	480
Metaphosphate as $NaPO_3$	0.24	0.32	0.08	7.70	8.22	8.58	7.15	5.35
Orthophosphate as $NaPO_3$	0.48	0.88	0.09	8.90	9.15	5.14	7.22	9.30
Total Hardness as $CaCO_3$	92	106	95	164	183	236	252	255
Calcium as $CaCO_3$	60	68	67	122	119	149	159	164
M-Alkalinity as $CaCO_3$	54	38	53	11	11	7	7	9
Turbidity as SiO_2	44.6	10.2	4.0	19	19	22	24	12
Copper as Cu = Soluble	0.06	0.06	0.06	0.09	0.09	0.11	0.10	0.13
" " " = Total	0.06	0.08	0.06	0.09	0.09	0.11	0.10	0.22
Total Iron as Fe	0.57	0.47	0.31	0.48	0.46	0.50	0.50	0.56
Sulphate as (SO_4)	10	10	13	158	157	216	245	270
Suspended Solids	26	8	3	8	8	10	11	5
Chromates as CrO_4	-	-	-	-	-	-	-	15.46
Manganese as Mn	0.06	0.05	0.06	0.08	0.08	0.17	0.28	0.06
Zinc as Zn	-	-	-	-	-	1.44	1.54	-
pH	7.56	7.43	7.10	6.72	6.72	6.02	5.87	6.02
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.839		$1.778	$1.782	$2.048
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-		5.71	4.49	5.70

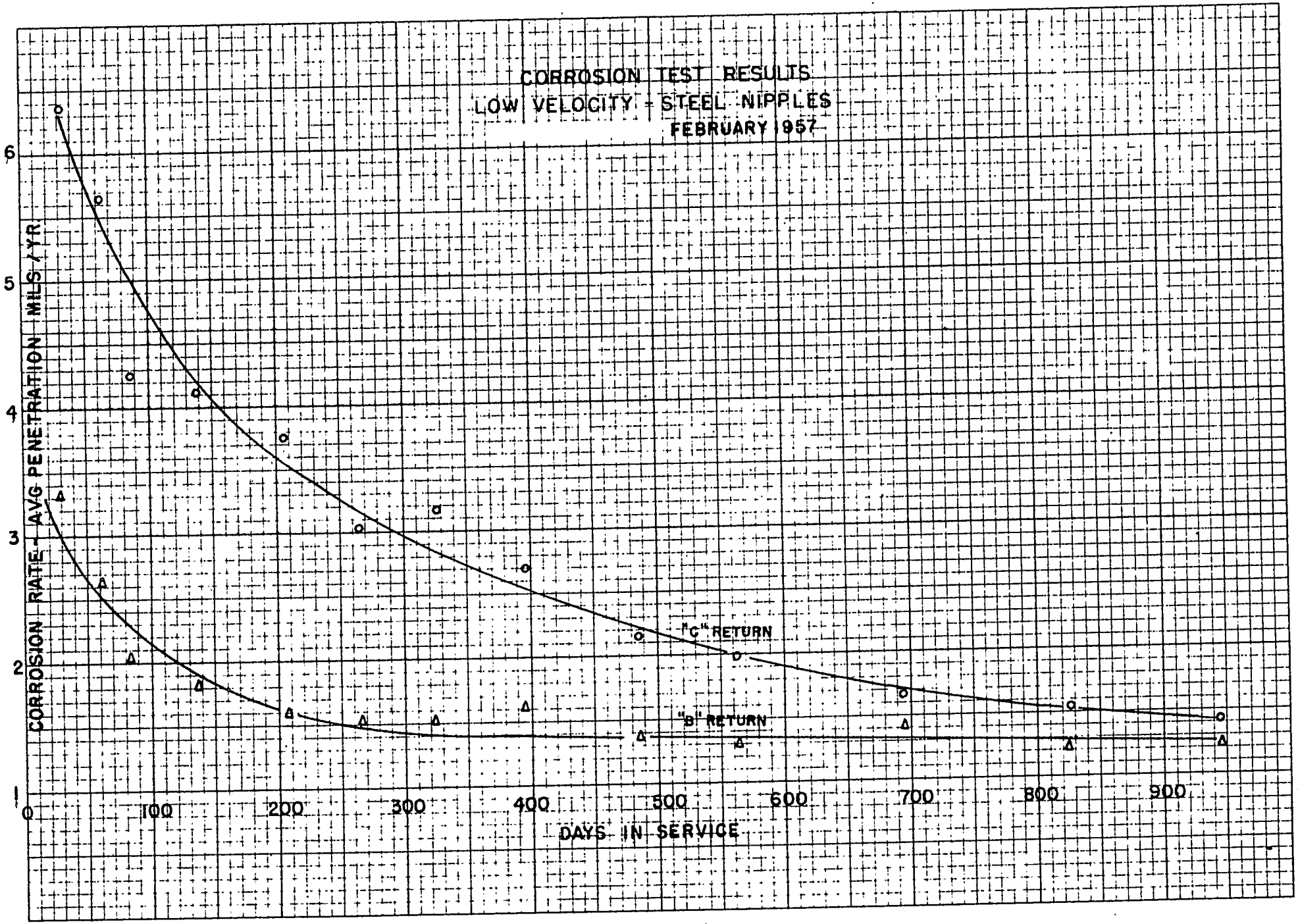
All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

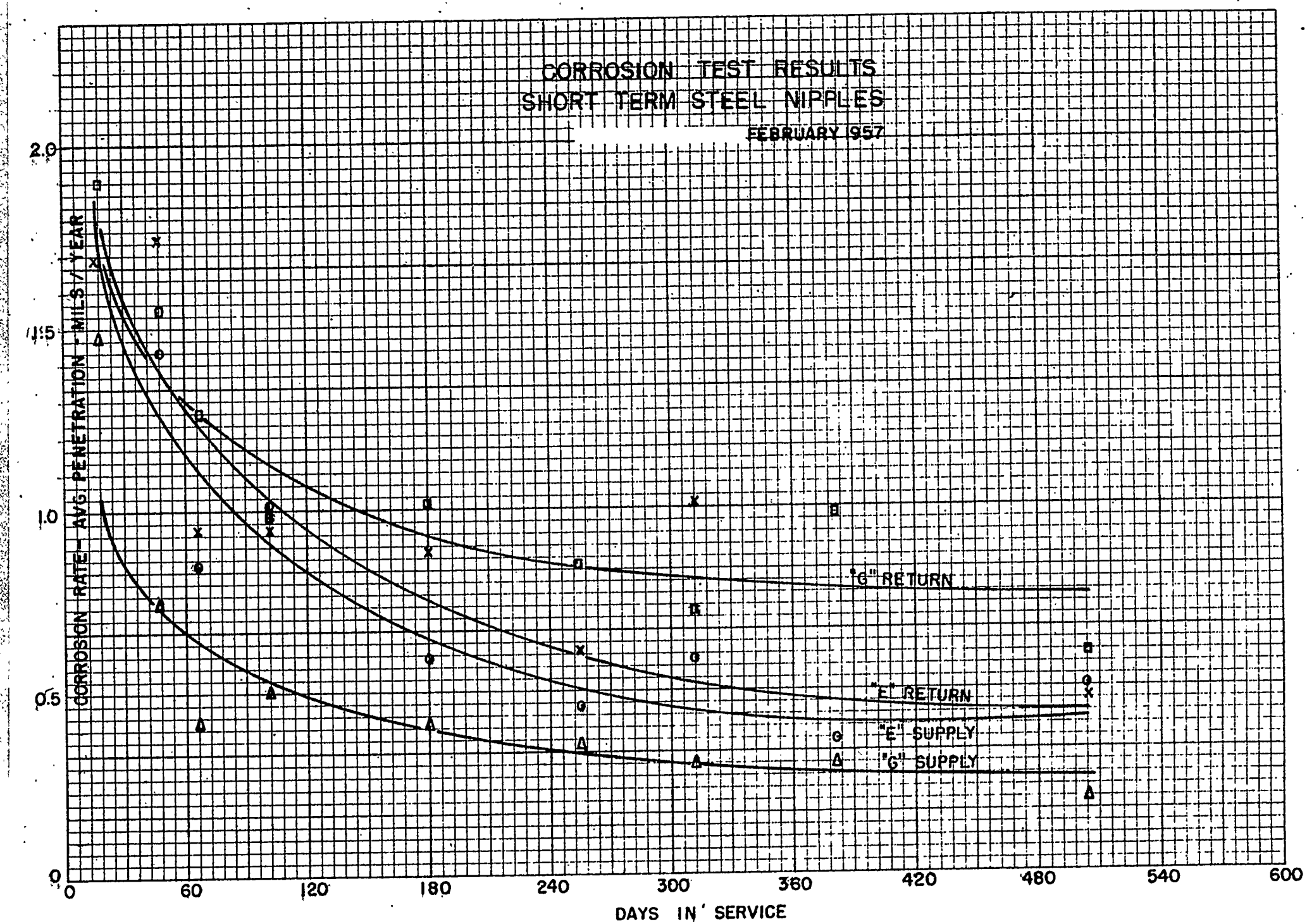
MONTHLY AVERAGE WATER ANALYSES - FEBRUARY, 1957

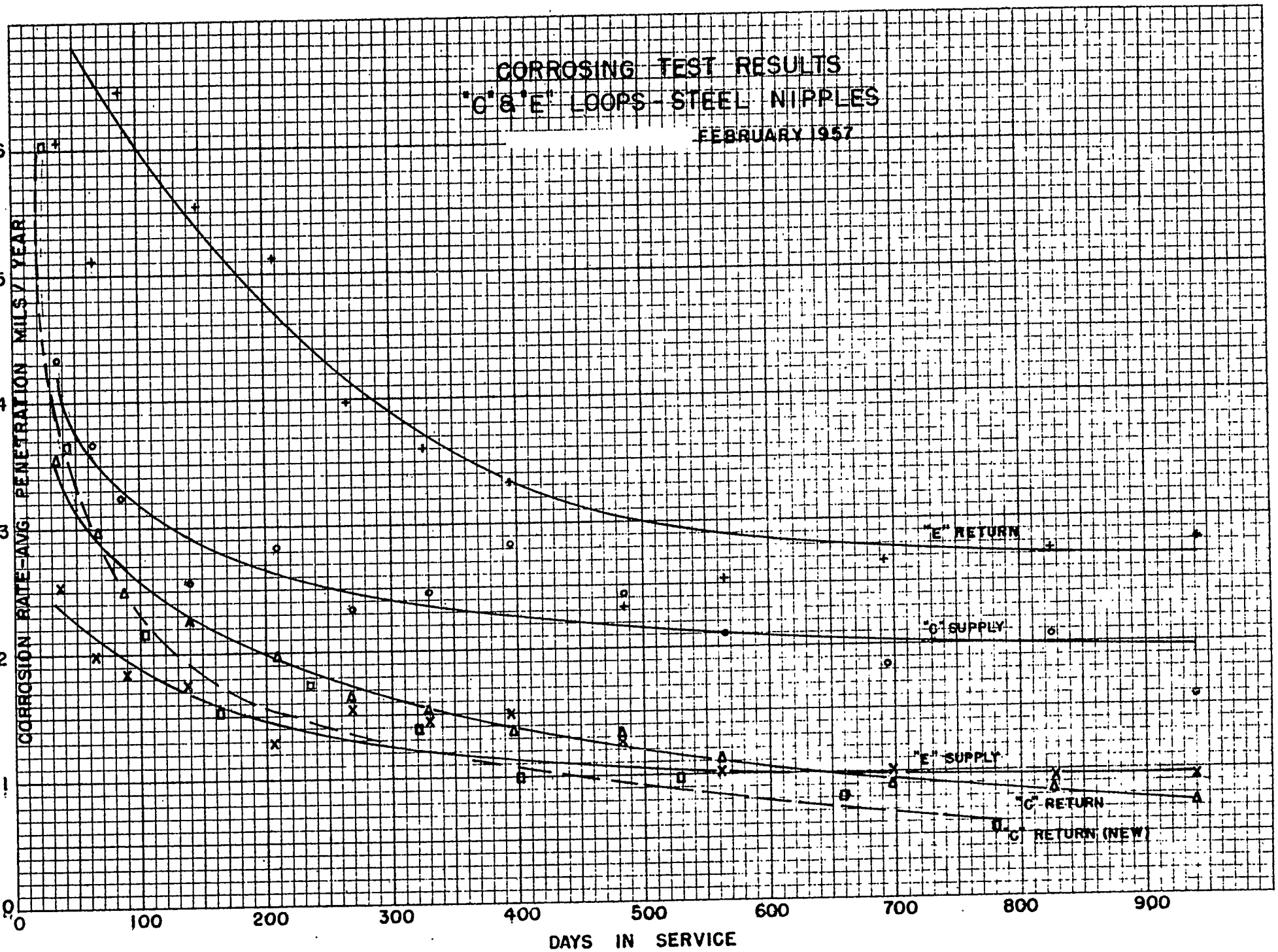
P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	130	126	122	230	231	282	341	398
Metaphosphate as $NaPO_3$	0.02	1.02	0.08	6.58	5.71	6.29	6.06	5.72
Orthophosphate as $NaPO_3$	0.26	0.49	0.09	8.42	9.26	4.50	7.64	11.37
Total Hardness as $CaCO_3$	76	76	76	141	133	161	178	212
Calcium as $CaCO_3$	50	50	50	87	95	105	113	125
M-Alkalinity as $CaCO_3$	42	42	36	11	11	7	7	15
Turbidity as SiO_2	25.7	11.7	3.4	19	19	22	22	20
Copper as Cu - Soluble	0.05	0.04	0.04	0.05	0.06	0.06	0.06	0.09
" " " - Total	0.06	0.06	0.06	0.07	0.07	0.08	0.10	0.12
Total Iron as Fe	0.55	0.48	0.30	0.56	0.54	0.52	0.46	0.56
Sulphate as (SO_4)	6	6	6	53	54	116	125	148
Chromates as CrO_4	-	-	-	-	-	-	-	20.1
Suspended Solids	14	7	1	10	10	11	12	10
Manganese as Mn	0.05	0.05	0.05	0.06	0.06	0.15	0.25	0.05
Zinc as Zn	-	-	-	-	-	1.53	1.70	-
pH	7.55	7.25	7.00	6.75	6.75	6.06	5.91	5.99
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.727		$1.879	$1.976	$2.055
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-		6.07	5.00	5.54

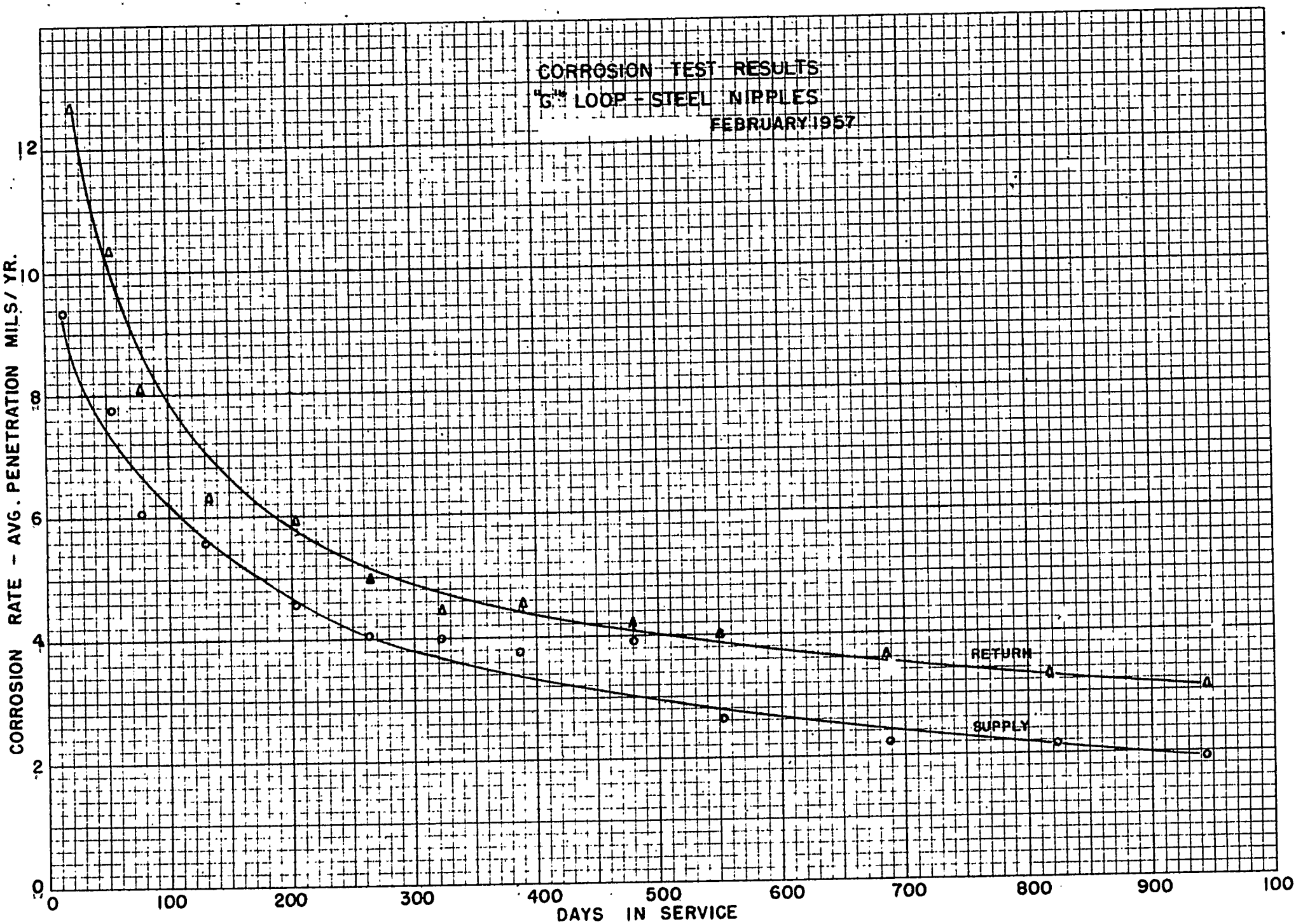
All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

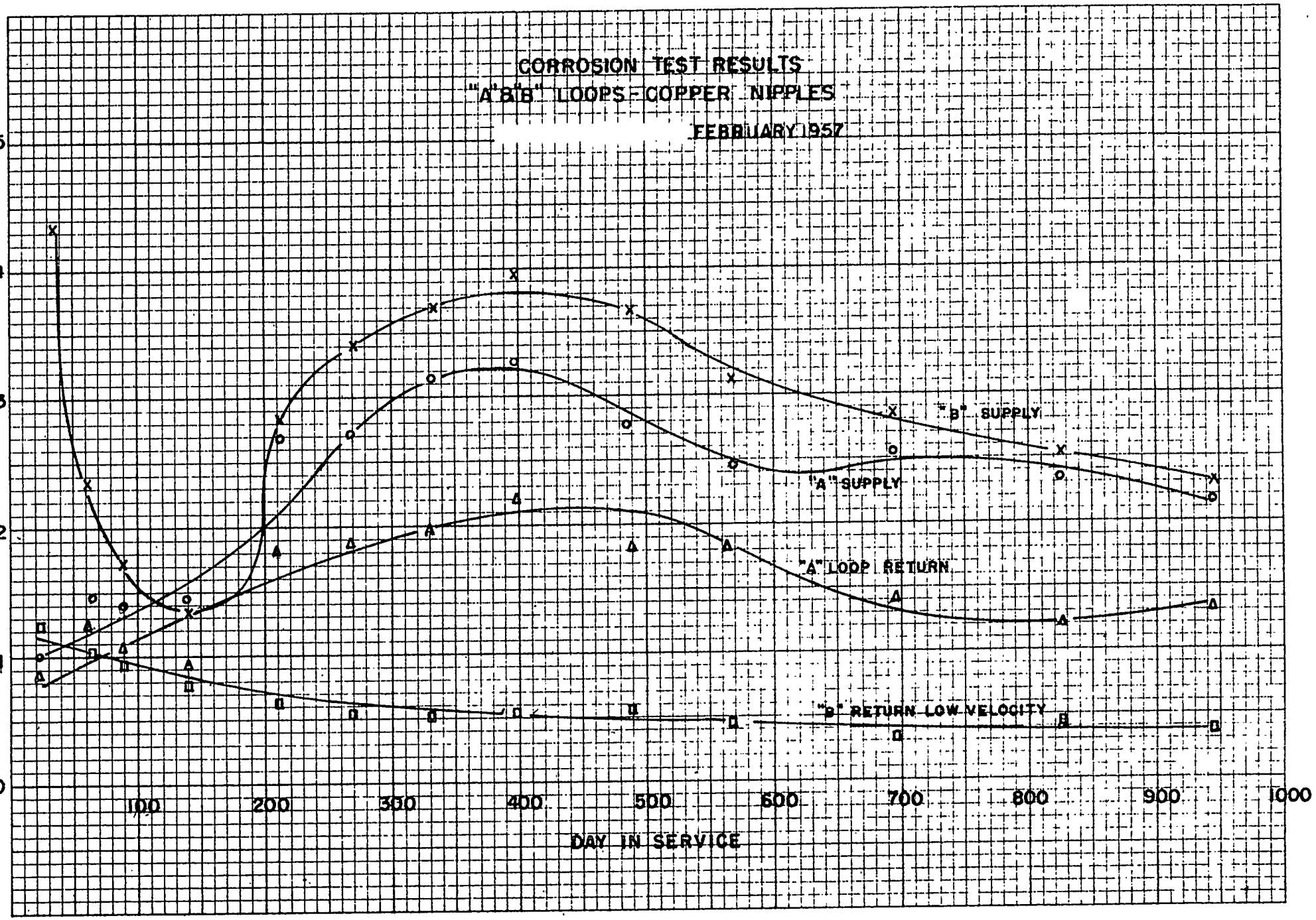


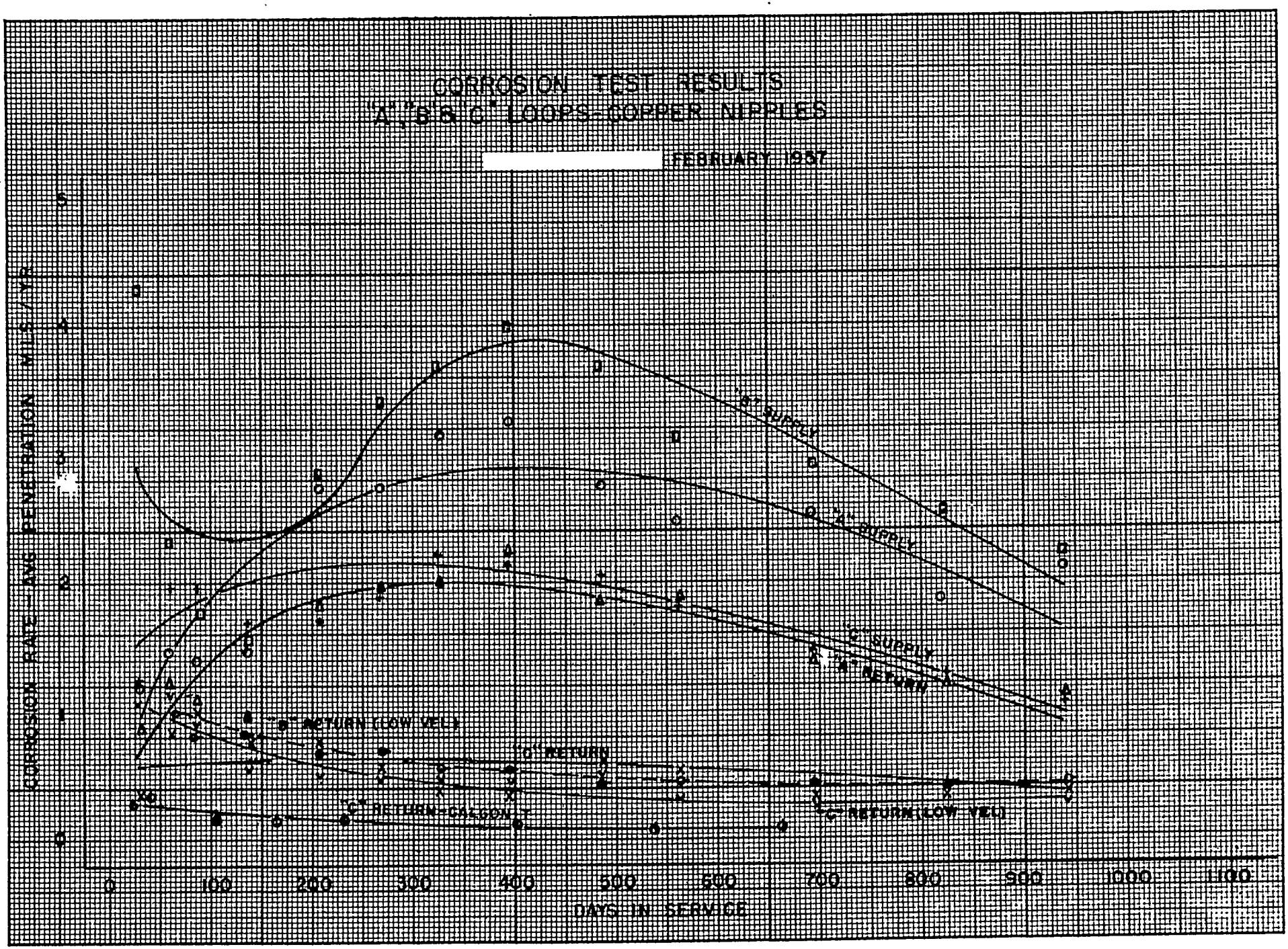


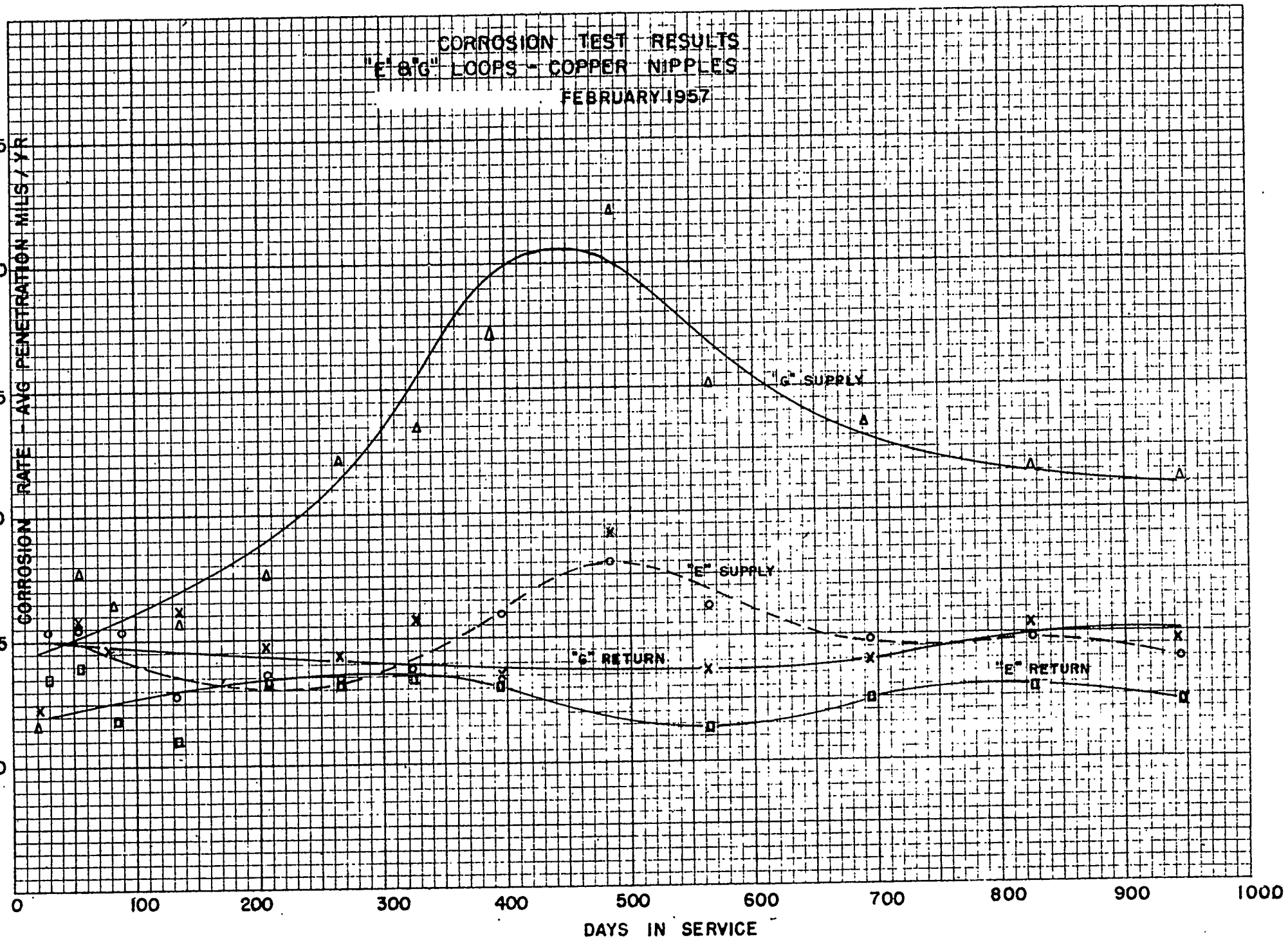


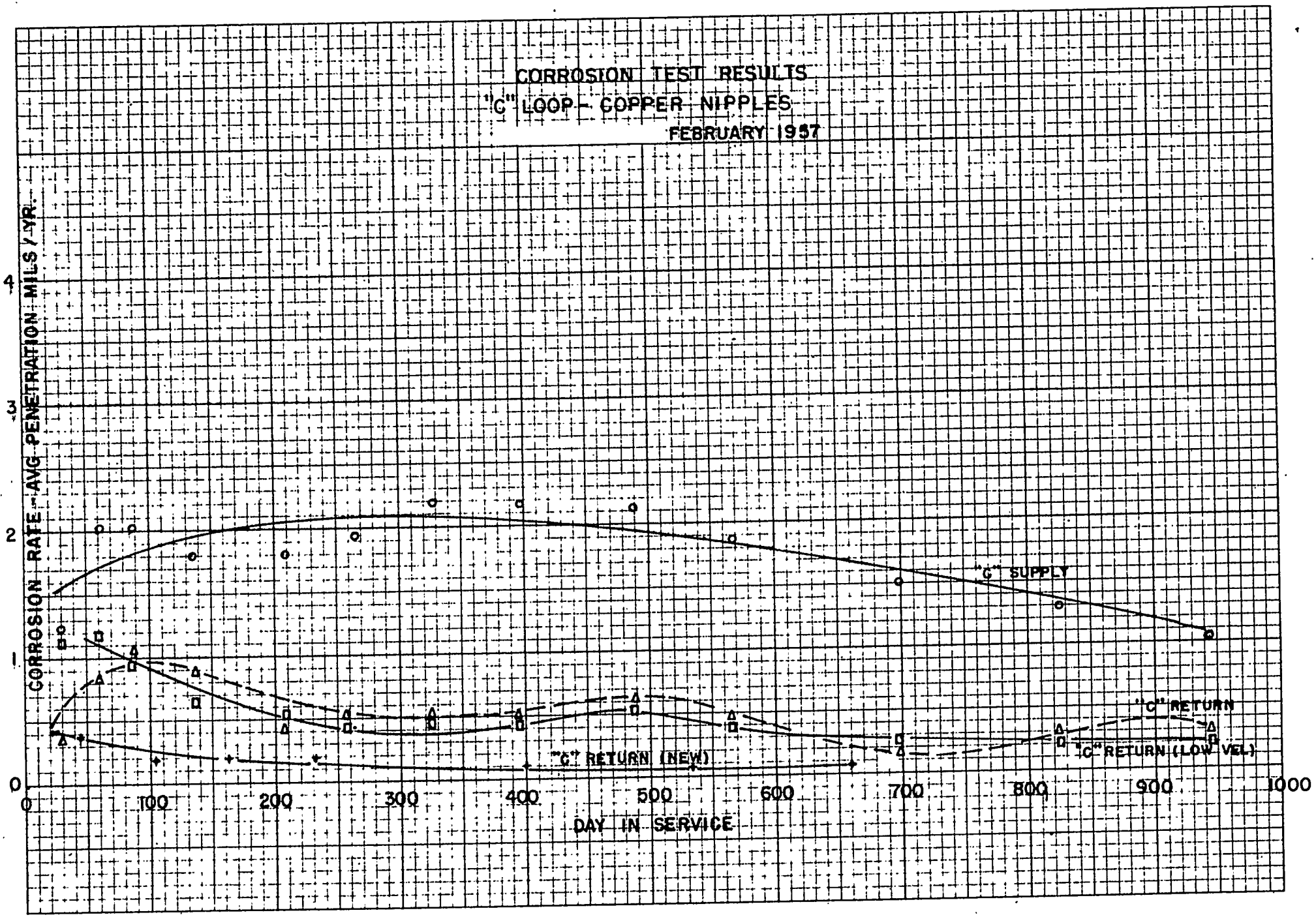


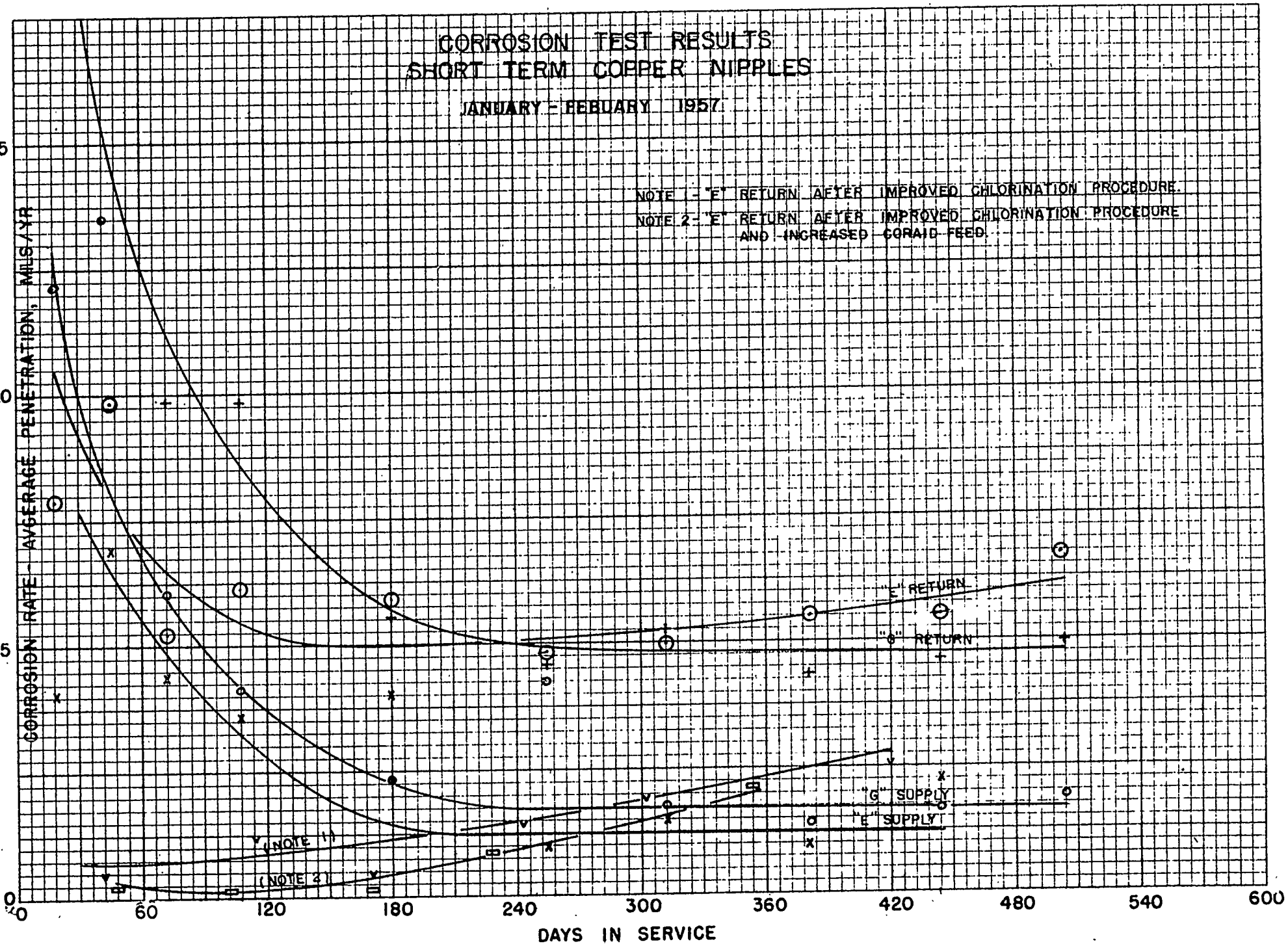












Date of Issue: July 25, 1957

Report Number: KP-570
Part No. 22

METALLURGY

To:

SUMMARY OF RECIRCULATING WATER TREATMENT TESTS FOR MARCH AND APRIL, 1957

C. C. Fowlkes and J. L. Gamble

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UNION CARBIDE NUCLEAR COMPANY
OAK RIDGE GASEOUS DIFFUSION PLANT
Production Division
Process Utilities Department

INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

A Division of Union Carbide and Carbon Corporation

To: Mr. H. G. P. Snyder
K-303-7

Plant: Oak Ridge Gaseous Diffusion

Date: July 25, 1957

Copies To: Attached Distribution

Subject: Summary of Recirculating Water Treatment Tests for March and April, 1957

KP-570, Part No. 22

In addition to discussions of operating results of all recirculating water systems, this report covers the Utilities Department corrosion test work and "short-term" corrosion curves for the K-31 and K-33 recirculating water systems.

Freon Condenser Corrosion

1) Metallurgical examination of six copper tubes removed from the steam-heated test condenser in the K-31 cooling water system after exposure periods ranging from 114 to 341 days revealed the most severe and consistent pitting encountered to date in the test condenser.[1] Pit diameters were generally about 1/32 inch or less, but the penetration was up to 30 per cent of the tube wall thickness. The pits contained cuprous oxide, brittle green deposits, and were covered by light brown tubercles. Only one tube, a standard copper one with 226 days' exposure, was not pitted, and this tube had numerous tubercles covering areas of severe surface attack.

2) The Engineering Development Department in their final report[2] on evaluation of materials of construction for condenser tubes concluded that the phosphorus-deoxidized copper tubes were as good as or better than any of the other materials tested.

3) The Calgon Company continues to blame the comparatively poor corrosion test results being obtained in K-31 recirculating water system upon the presence of mercury in the make-up water. They recommended[3] clarification of all make-up water to this system and discussed the mercury concentration found by them in the K-31 recirculating water samples.

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[1] Technical Division Weekly Report for the Week Ending April 18, 1957, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, April 22, 1957, (KLI 3800, Part 43). (Secret)

[2] R. G. Knight, report to Mr. S. H. Smiley, Test Condenser Evaluation of Condenser Tube Materials of Construction, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, March 6, 1957, (KLD-402, Part 2).

[3] Letter from Mr. J. P. Kleber, Calgon Company, to Mr. K. M. Jones dated March 8, 1957.

4) In a meeting[4] with representatives of the Calgon Company, data and information were presented which showed that the Calgon-Coraid treatment being used in "E" loop was not giving as good corrosion test results as the chromate-phosphate treatment (Betz Dianodic) being used in "G" loop. Probolog data, copper test nipples, and test condenser results were submitted as evidence.

Mr. J. P. Kleber of the Calgon Company readily agreed that the corrosion test work indicated comparatively poor results on "E" loop, but he said that the systems were not comparable due to different make-up waters. He still blamed the mercury concentration in the untreated Poplar Creek water for the copper pitting. He stated that the make-up water treatment at K-33 would remove at least 50 per cent of the mercury continuously, and probably considerably more during periods of unusually high mercury concentrations. Mr. Kleber also stated that in the final analysis the plant operating data should be seriously considered, as it was his understanding that the K-31 condenser failure rate, despite longer service life, was much less than that presently being experienced in K-33.

Mr. Kleber made the following recommendations for recirculating water treatment changes for "E" loop:

a) Raise the total phosphate level in K-31 to 20 ppm, and then to 25 ppm if heat transfer loss was not too great. (This was recommended for the purpose of increasing deposition on tubes to prevent contact with mercury in the make-up water.)

b) Chlorinate the recirculating water once a day, raising the chlorine residual to one ppm and hold for 30 minutes, but do not chlorinate over 4 hours. Continue to feed 4 ppm Coraid after chlorinating and 2 ppm 10 to 12 hours later.

c) Use only coagulated clarified make-up water for "E" loop.

These recommendations were placed in effect on April 30, 1957.

5) To evaluate the corrosion protection offered to new condensers in K-31 by the Calgon-Coraid treatment, two recently retubed condensers were inspected with the Probolog. The first was a condenser in K-602-3.5 which had been in service for 22 months, 5 months prior to the start of the Calgon-Coraid treatment. This condenser was found to be severely pitted. Tubes removed

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[4] J. L. Gamble, Minutes of Meeting With Calgon Company Representatives Regarding Copper Corrosion in the K-31 Recirculating Water System, April 29, 1957, written and distributed May 7, 1957.

from this condenser and split for inspection confirmed the Probolog evidence. The second condenser had 6 months' service in the A-line--cooled test cell in K-602-4.2, with a controlled water velocity of 5 feet per second. It was found to be pitted, somewhat severely considering the service time. It was concluded that Calgon-Coraid was not protecting new condensers against pitting corrosion.

To evaluate the protection offered to new condensers by the Betz Orocol No. 181 in K-33, a condenser in K-902-7.10 even was examined with the Probolog. This condenser had 16 months' service during which only Orocol No. 181 was used. No evidence of any pitting was found.

Tests and operating results of the individual loops are as follows:

A Loop (K-25 East) and B Loop (K-25 West)

The combined "A" and "B" loop pumpages dropped from 61 to 54 million gallons per day. This reduction is due primarily to closing down the K-306 section, which was completed on March 28. The water control valve position in K-309-2 averaged closing from 48 to 46 per cent open, and the control valve average position in K-304-4 opened from 26 to 39 per cent open.

C Loop (K-27/K-29)

Total pumpage requirements increased slightly, from 57 to 58.5 million gallons per day. There was no change in the K-27 water control valves as indicated by the K-402-3 cells. The K-29 water control valves, as indicated by the K-502-1 cells, averaged closing from 45 to 42 per cent open despite daily peaks as high as 55 per cent open.

There were no K-29 condenser failures during this report period. However, one condenser, K-502-2.8, was acid cleaned for 45 minutes to improve heat transfer. No leaks developed as a result of this cleaning.

E Loop (K-31)

Pumpage requirements dropped from 83 to 81 million gallons per day. Improvements in heat transfer are also reflected in a return water temperature increase of 1° to 145.5° F and the average closing of the water control valves, as indicated in K-602-3, from 55 to 47 per cent open.

There was one condenser failure during this report period--K-602-1.1 on April 29, 1957; 6 tubes were plugged.

G Loop (K-33)

Apparently there was some loss of heat transfer during this report

period, as the pumpage requirements increased from 227 to 238 million gallons per day with a return water temperature drop of 2° to 1.7° F. The average water control valve position as indicated in K-902-4 closed from 66 to 64 per cent open.

Two leaking condensers were repaired or replaced during the report period; they are as follows:

1) K-902-4.1 even - March 18, 1957; leakage of 24 lb/day. As this condenser had been plugged three times previously, it was replaced with a new condenser.

2) K-902-3.1 even - March 25, 1957; leakage of 35 lb/day; 1 tube leak.

With the consent of Betz Laboratories, Inc., Calgon was added to sodium dichromate for a period of 17 days in March to use up a supply of chromate that had been previously purchased. A 1:1 mixture of Calgon and sodium dichromate was supposed to be equivalent to Betz No. 181 Orocol. However, in actual practice it was found that higher than normal metaphosphate residuals could be maintained at lower than normal feed rates. It was calculated that 414 pounds of Calgon would be equivalent to 700 pounds of the phosphate in Orocol No. 181.[5] As a result of this trial run, Betz Laboratories, Inc. was requested to formulate their No. 181 Orocol with a better grade of phosphate. They have agreed to do this, and their new No. 181H formulation will be prepared from hexametaphosphate instead of the tripolyphosphate previously used.

K-892 Test Loop

A 70-day test in the K-892 recirculating water test loop using no corrosion inhibitor was completed. This test was run to establish a base from which the relative performance of different corrosion inhibitors can be evaluated. Operating conditions for this test were:

Supply temperature	90° F
Return temperature	130° F
Concentration ratio	3:1
Water velocity	4.0 feet per second
pH	7.8 to 8.0

Make-up water was supplied from the plant sanitary water system (Clinch River). No chlorine was added to the test loop except that available in the make-up water supply. Heat transfer conditions remained very good throughout the test. Thin uniform deposits were found in the tubes upon examination except in the inlet ends which were clean. No evidence of pitting was found, but some microscopic etching of the portions of the tube which were not covered by deposits was noted. Corrosion rates

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[5] Letter from Mr. M. A. Fletcher to Mr. H. G. P. Snyder, "Results and Analyses of Tests on Use of Substitute Chemicals for Corrosion Prevention, K-892" dated March 19, 1957.

calculated from weight loss of nipples are attached (Figure 1) and are fairly high a s was expected.

K-31, K-33 Cathodic Protection

Design work for the installation of a cathodic protection system for the prevention of external corrosion on the underground recirculating water lines for K-31 and K-33 was completed. The most economical method was found to be rectifiers to supply direct current potential to steel rails (available at no cost) buried adjacent to the water lines. Purchasing has been directed to advertise for bids for a lump-sum contractor.

Monthly Average Water Analyses

Attached are separate monthly average water analyses sheets for each month covered by this report.

The "G" loop chemical treatment costs for March were considerably less than in April, due to 17 days' operation with a Calgon--sodium dichromate mixture in place of No. 181 Orocol. It will also be noted that phosphate reversion to the ortho form was much less in March than in April. As mentioned previously, Betz Laboratories, Inc. has agreed to furnish us with a better grade of phosphate.

Some of the soluble copper concentrations are higher than normal, particularly "G" loop in April with 0.16 ppm. Previously we have had difficulty with steel pitting at soluble copper concentrations of over 0.10 ppm.

Graphs of Steel and Copper Corrosion Rates

Of the attached corrosion curves, Figures 2 and 4 give the latest steel and copper corrosion rates of "E" and "G" loops, respectively. These curves are self-explanatory and are considered satisfactory. Figure 3, with an elongated ordinate scale, gives a magnified view of the "E" loop return copper corrosion rates after changes in chlorinating procedure and making a large increase in the Coraid feed rate. From these curves we conclude that:

1) While still at a low average corrosion rate, the rate of increase indicates a pitting type of attack.

2) The increased Coraid feed rate did little good.

C. C. Fowlkes
C. C. Fowlkes

Approved: L. I. Anthony
L. I. Anthony
Process Utilities Department

J. L. Gamble
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MONTHLY AVERAGE WATER ANALYSES - MARCH, 1957

P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	121	114	120	273	270	336	397	495
Metaphosphate as $NaPO_3$	0	0.24	0.02	5.52	5.35	4.38	4.98	7.46
Orthophosphate as $NaPO_3$	0.30	0.46	0.08	8.84	9.18	5.19	7.17	11.11
Total Hardness as $CaCO_3$	92	83	82	156	143	175	203	239
Calcium as $CaCO_3$	66	53	53	89	95	113	123	140
M-Alkalinity as $CaCO_3$	59	55	58	12	11	7	7	10
Turbidity as SiO_2	12.3	9.5	3.2	16	16	21	19	18
Copper as Cu - Soluble	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.10
" " " - Total	0.06	0.07	0.06	0.09	0.10	0.08	0.10	0.13
Total Iron as Fe	0.66	1.42	0.57	1.32	1.33	1.59	1.37	1.56
Sulphate as (SO_4)	6	8	6	50	51	100	116	134
Chromates as CrO_4	-	-	-	-	-	-	-	20.65
Suspended Solids	3.75	10.0	0.75	7.69	7.76	10.76	8.84	5.90
Manganese as Mn	0.05	0.05	0.05	0.067	0.06	0.127	0.205	0.06
Zinc as Zn	-	-	-	-	-	1.54	1.63	-
pH	8.00	7.96	7.40	6.77	6.80	6.10	5.87	6.03
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz* Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.752		$1.416	$1.854	$1.400
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-		4.73	4.69	3.76

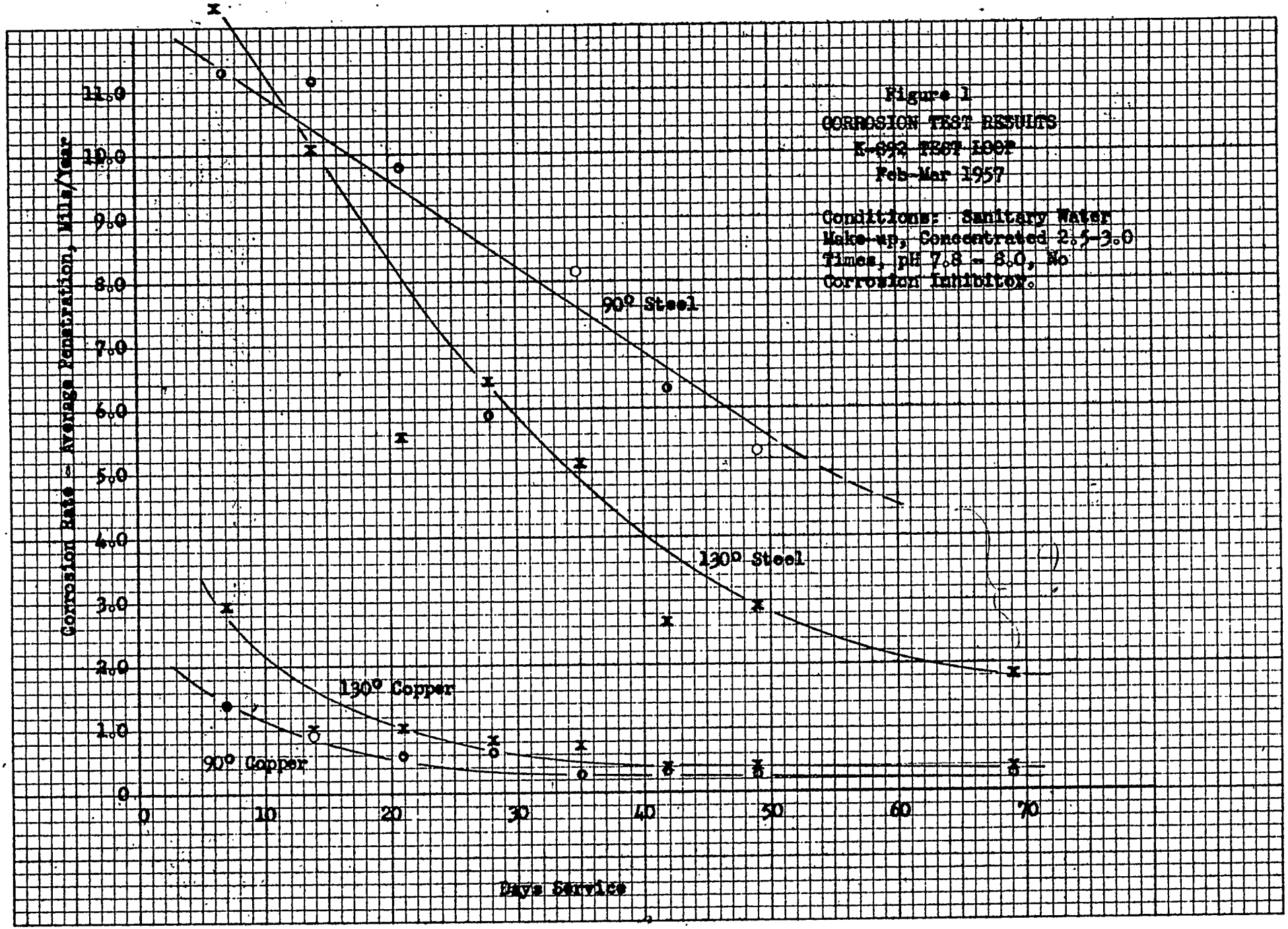
All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

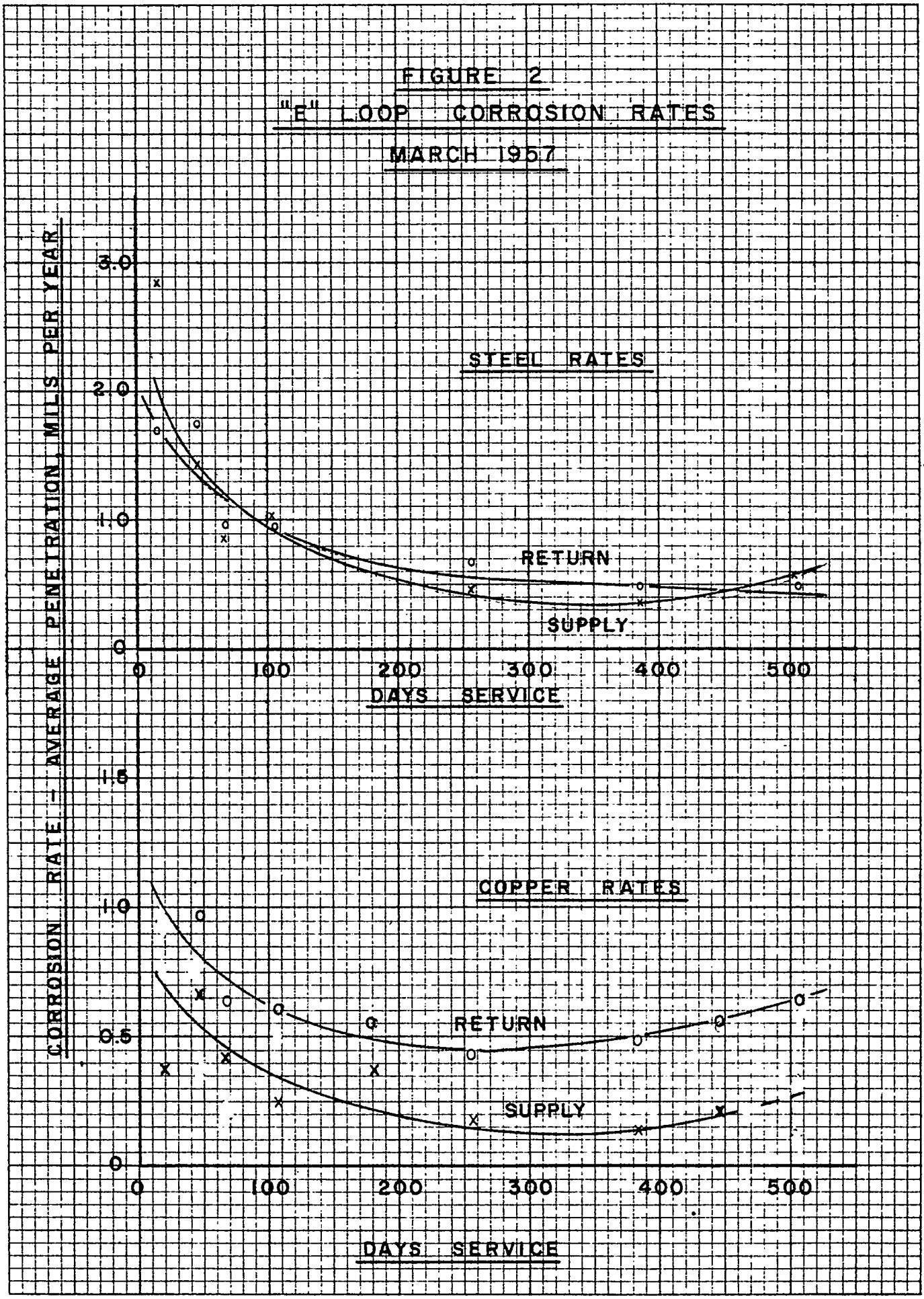
*Includes 17 days of Calgon-chromate mixture.

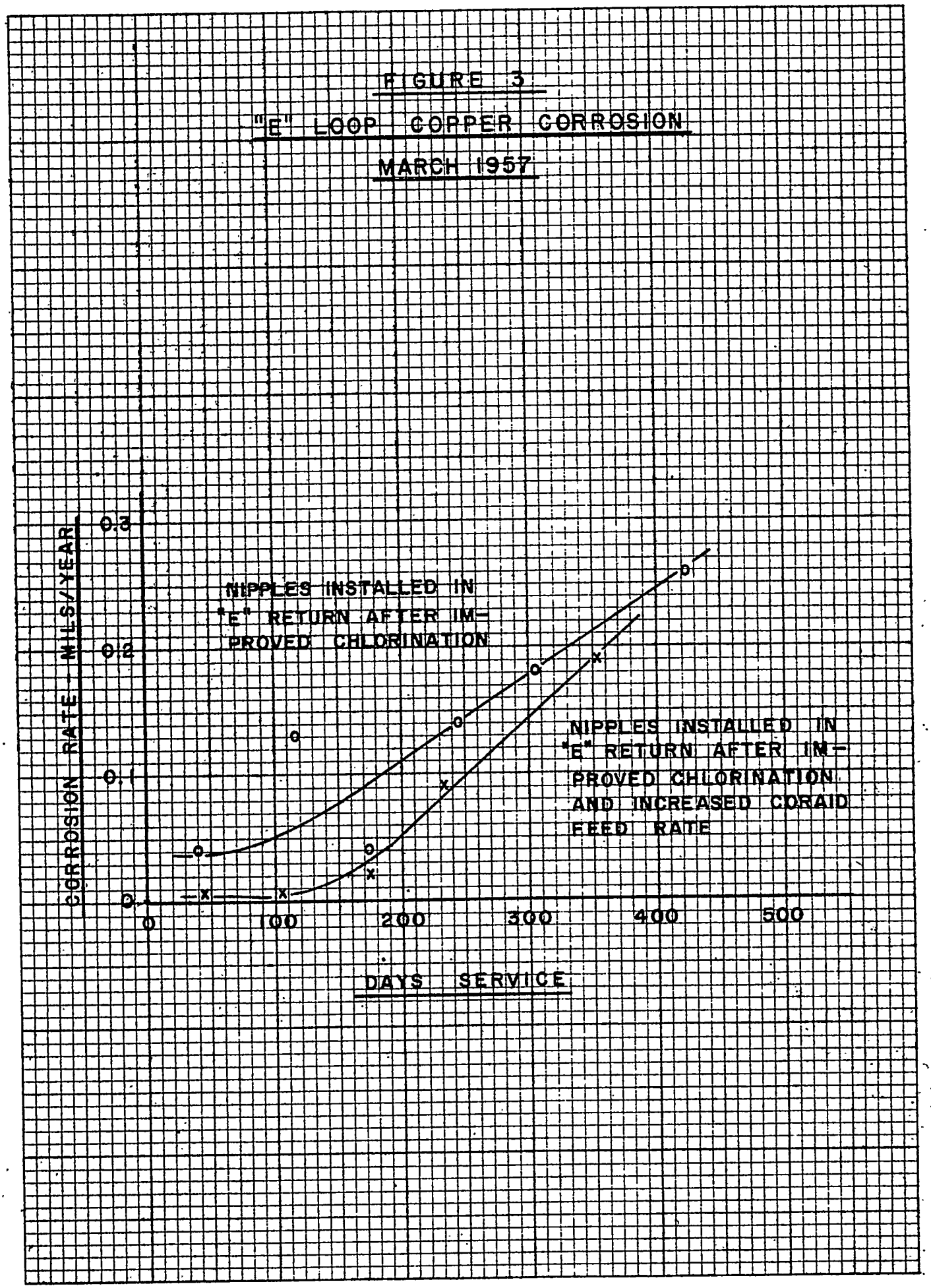
MONTHLY AVERAGE WATER ANALYSES - APRIL, 1957

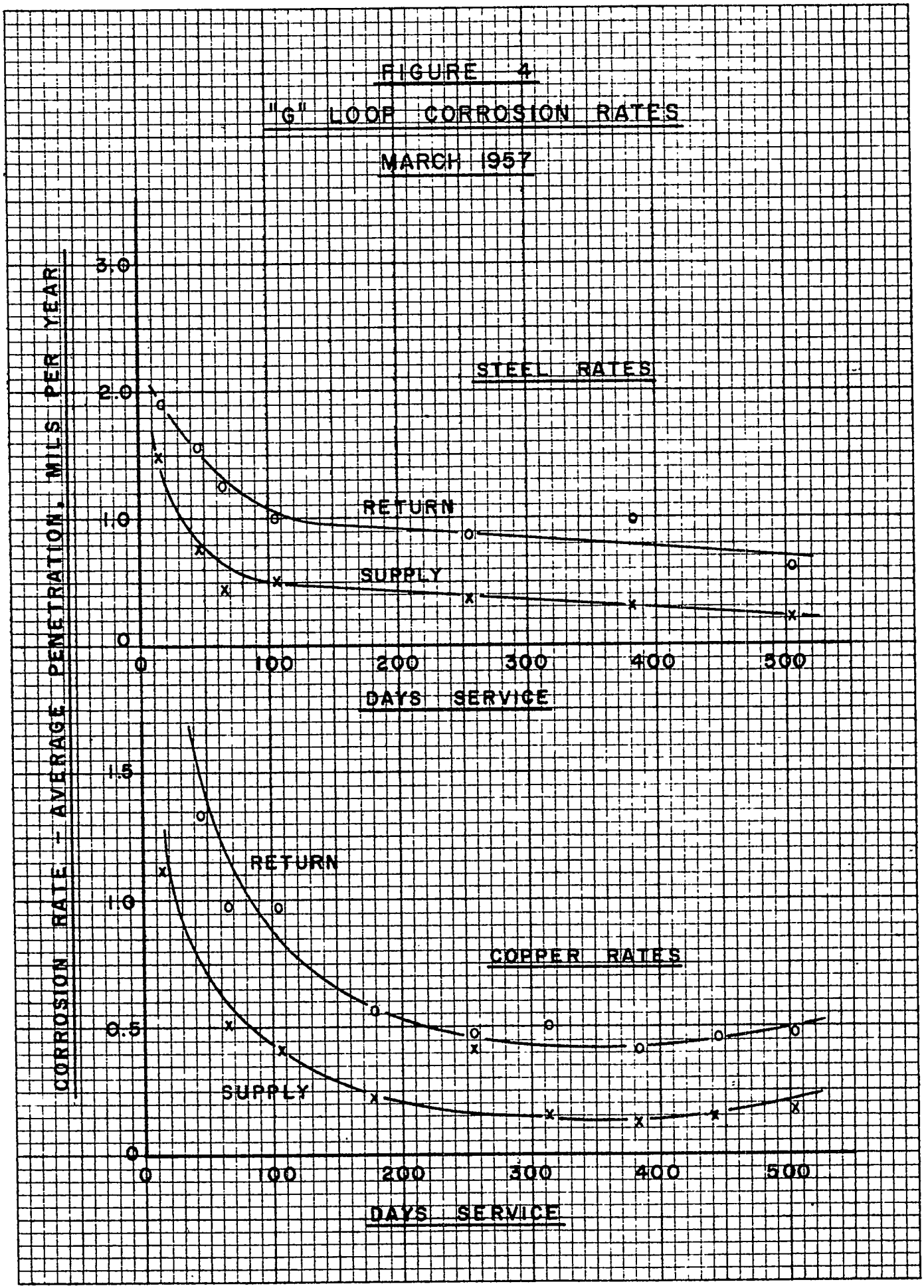
P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	136	147	144	301	297	409	459	645
Metaphosphate as $NaPO_3$	0	0.25	0.20	7.09	7.63	7.72	7.45	6.63
Orthophosphate as $NaPO_3$	0.37	0.59	0.10	10.66	10.25	5.41	8.08	15.08
Total Hardness as $CaCO_3$	103	97	102	183	178	217	244	326
Calcium as $CaCO_3$	63	56	59	92	90	132	131	194
M-Alkalinity as $CaCO_3$	60	62	52	12	12	7	9	10
Turbidity as SiO_2	10.4	11.4	2.8	12.8	13.4	21.2	18.8	16.7
Copper as Cu - Soluble	0.06	0.07	0.05	0.06	0.08	0.07	0.07	0.16
" " " - Total	0.06	0.07	0.06	0.09	0.10	0.08	0.09	0.16
Total Iron as Fe	0.64	0.70	0.48	1.37	1.42	1.54	1.57	3.40
Sulphate as (SO_4)	11	11	9	54	57	90	96	113
Chromates as CrO_4	-	-	-	-	-	-	-	22.69
Suspended Solids	4.4	4.0	0.5	4.9	5.0	7.7	14.3	6.9
Manganese as Mn	0.06	0.06	0.05	0.06	0.08	0.13	0.20	0.60
Zinc as Zn	-	-	-	-	-	1.51	1.58	-
pH	7.50	7.40	7.10	6.76	6.80	6.00	5.93	6.00
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.920		$1.612	$1.936	$2.001
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-		5.62	4.89	5.48

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.









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Report Number: KP-570
Part No. 23

Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, Operating Contractor for the U.S. Atomic Energy Commission.

SUMMARY OF RECIRCULATING WATER TREATMENT TESTS FOR MAY AND JUNE, 1957

C. C. Fowlkes and J. L. Gamble

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INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

A Division of Union Carbide and Carbon Corporation

To: Mr. H. G. P. Snyder
K-303-7

Plant: ORGDP

Date: August 23, 1957

Copies To: Attached Distribution

Subject: Summary of Recirculating Water Treatment Tests for May and June, 1957

KP-570, Part No. 23

Summary

This report outlines the operating results of all recirculating water systems, changes in water treatment procedures, and results of corrosion investigations during May and June, 1957. Included are corrosion curves for the K-27, K-29, and K-31 recirculating water systems.

Changes in Water Treatment

Analysis of recent data obtained from the K-29 and K-31 freon condensers indicated that serious corrosion was occurring on the water side of the copper heat exchanger tubes.[1] These data included:

1. Inspection of copper tubes from steam-heated test condensers. Several of these tubes from both K-29 and K-31 have been found pitted, some severely after only short service time.[2] (These inspections are described in greater detail on page 4 of this report.) However, some of the tubes with even longer service time were not pitted; no correlation with any operating variable was found. A Probolog inspection of all steam-heated condensers confirmed the existence of the pitting attack in K-29 and K-31.[3]

2. Probolog data from freon condensers.[4] One condenser in K-31 with only six months' service during which only the Calgon-

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[1]Letter from Mr. L. L. Anthony to Mr. H. G. P. Snyder, "Modified Make-up Water and Recirculating Water Treatments and Chromate Disposal," dated June 7, 1957.

[2]Technical Division Weekly Report for the Week Ending May 31, 1957, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, June 3, 1957, (KLI 3800, Part 49). (Secret)

[3]Letter from Mr. J. L. Gamble to Mr. L. L. Anthony, "Summary of Probolog Test Results of Steam-Heated Test Condensers in K-29, K-31 and K-33," dated May 31, 1957.

[4]J. L. Gamble, Progress Report, Corrosion Control and Engineering, Report No. 5, May 3, 1957.

Coraid treatment was used was found to be pitted. Another condenser in K-31 with twenty-two months' service was found to be badly pitted. One condenser with three months' service was not pitted; however, it had been operated at 7.5-foot-per-second water velocity.

3. Copper test nipples. Test nipples recently removed from the K-31 recirculating water system have contained pitted areas.

A similar investigation of the K-33 recirculating water system was made, and no indications of pitting of new copper condenser tubing were found.

In comparing the water systems, two basic differences were noted:

1. The corrosion inhibitor. Calgon-Coraid treatment was being used in K-29 and K-31, while Betz Dianodic (No. 181) was being used in K-33.

2. Make-up water. The make-up water source for all systems was Poplar Creek; but the K-33 water supply was clarified, while, for the most part, the water for K-29 and K-31 was unclarified (except for periods of high turbidities in Poplar Creek).

Due to the severity of the corrosion attack in K-29 and K-31, it was decided that an immediate change should be made.[5] While it is possible that the copper pitting was due solely to some contaminant in the make-up water, as was concluded by Mr. J. P. Kleber of the Calgon company,[6] it was felt that this risk should not be taken, especially since a proven, successful treatment was available. Accordingly, on June 11, 1957, the Calgon-Coraid treatment was discontinued in "C" and "E" loops, and the Betz Dianodic (No. 181) treatment was started. The use of only clarified make-up for K-31--started previously--will be continued, and clarified make-up for K-29 will be made available as soon as possible.

In order to limit the concentration of chromates in Clinch River, which receives blowdown from all recirculating water systems, the chromate level in the K-33 recirculating water system was reduced from 20 ppm to 10 ppm.[7] This step was taken after the Betz Laboratories advised that adequate corrosion protection would be provided at the lower chromate level,[8] and after Probolog inspection of a Paducah condenser operating

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[5]Letter, Anthony to Snyder, June 7, 1957, op. cit.

[6]Letter from Mr. J. P. Kleber to Mr. L. L. Anthony, "Cooling Water Treatment, K-25 Area," dated May 6, 1957.

[7]Letter from Mr. L. L. Anthony to Mr. H. G. P. Snyder, "Concentration of Chromates in Clinch River," dated May 20, 1957.

[8]M. A. Fletcher, Minutes of Meeting with Betz Laboratories Representatives Regarding Various Water Treatment Problems, May 22, 1957, written May 24, 1957.

at this level for three months (after four months at the 20 ppm level) showed no evidence of pitting.[9]

No change in treatment of "A" and "B" loops is planned, since no difficulties have been experienced and the straight Calgon treatment is very economical.

Freon Condenser Corrosion Investigations

The more significant developments concerning the freon condenser corrosion problem were:

1. Four tubes from a K-31 freon condenser, which had been cleaned at K-1401, were examined recently.[10] As a result of a head gasket failure in the acid circulation system, which occurred during the cleaning cycle, these tubes had been exposed to acid for a 3- to 4-hour period instead of the customary 20-minute cycle. Owing to inability to flush the system, the acid had remained stagnant in the tubes until repairs could be made. The four tubes presented the first evidence of metal loss that has been found on tubes that have been cleaned in the acid-cleaning loop. A very interesting pattern of attack was observed in two tubes removed from pass 1-2. These tubes exhibited severe etching of the surface with marked reduction in wall thickness. However, at areas where tuberculation and pitting had occurred in service, there were raised areas of copper which had a burnished appearance and had suffered no visible attack. Wall thickness measurements showed that these areas were of the same order of thickness as a new tube. This indicates that the tubercle and its underlying scale had functioned to protect the underlying copper against attack by the acid. A thickness loss of as much as 4 mils had occurred in portions of the tube that had not been protected by the hard scale of tubercles.

   The two tubes examined from pass 3-4 exhibited a moderately severe, general etching of the surface, but the metal loss was much less than that observed in the tubes from the first two passes.

2. Four tubes from the K-29 supply test condenser were examined by the Metallurgy Department.[11] A powdery, cream-colored scale about 0.02 inch thick over a thin, tan, brittle, noncontinuous subscale was found on each of the tubes.

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[9] J. L. Gamble, Corrosion Control and Engineering, Report No. 7, June 12, 1957.

[10] Technical Division Weekly Report for the Week Ending May 10, 1957, (KLI 3800, Part 46). (Secret)

[11] Technical Division Weekly Report for the Week Ending May 31, 1957, (KLI 3800, Part 49). (Secret)

The standard copper degreased tube with 116 days' service was the most severely attacked. Narrow pits that penetrated about two thirds of the tube wall and numerous large shallow pits were found. The pits contained cuprous oxide and brittle, green deposits and were covered by tan, powdery tubercles. The standard copper tubes exposed during the same period had a few tubercles and areas that were in the early stages of pitting. The standard copper degreased tube with 189 days' exposure had several large pits (greater than 1/32 inch in diameter) filled with cuprous oxide and corrosion products. The standard copper degreased tube exposed for 318 days, including 69 days with Calgon-T-treated cooling water, was only slightly attacked and no pits were found.

About 50 per cent of the tubes previously examined from this condenser had been pitted to some extent, but no pits with excessive penetration were found. The pitting did not seem to be a factor of length of service or of tube material. Both the frequency and severity of pitting in the standard copper and standard copper degreased tubes have increased since June, 1956, when the Calgon-Coraid treatment was substituted for the Calgon T water treatment.

3. As a result of the inspection of one batch of copper tubes received by Goslin-Birmingham from Wolverine which were found to be contaminated with dirt and oil, the decision was made that these tubes should be cleaned with trichloroethylene, after assembly into the shells, to remove the oily film and flush out loose dirt.[12] The degreasing treatment will be followed by a mild acid cleaning in the condenser cleaning loop to remove stains and lay down a uniform protective coating. Inspection of a retubed K-31 condenser recently received from Goslin-Birmingham disclosed the presence of contamination in the tubes much in excess of that found in the "as-received" tubes. The cleaning procedure proposed should adequately remove the additional foreign matter. A boroscopic examination of the first condenser cleaned by this method indicated satisfactory results.

4. Metallurgical examination of standard copper degreased tubes and standard copper degreased and water-oxidized tubes with 216 and 361 days' service in the test condenser in the K-33 return water showed them to be coated with a very thin, powdery scale over a thin film of subscale.[13] The tubes with 216 days' service were in very good condition with only a very light etching of the tube surface, while the tubes with 361 days' service had small blisters of copper and small areas of moderate attack. No

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[12] J. L. Gamble, Minutes of Meeting to Discuss Freon Condenser Cleaning, May 29, 1957, written June 4, 1957.

[13] Technical Division Weekly Report for the Week Ending June 28, 1957, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, July 1, 1957, (KLI-4145, Part 1). (Secret)

pits were found.

A standard copper degreased tube and an arsenical annealed tube with 262 days' service and a standard copper annealed and degreased tube with 114 days of service in the test condenser in the K-31 return water line had a thin, powdery scale with little or no subscale. All the tubes were pitted and had areas of severe surface attack. The older tubes had the larger and deeper pits with penetration of as much as 35 per cent of the wall thickness.

Graphs of Steel and Copper Corrosion Rates

Figure 1 is an over-all picture of the corrosion rates obtained with copper test nipples in "C" and "E" loops while using the Calgon-Coraid treatment. Figures 2 and 3 are the results of long-term steel and copper test nipples in "C" and "E" loops. All corrosion rates are considered satisfactory except for the steel return in "E" loop, which is somewhat higher than desirable although not significantly.

Corrosion rates on copper test nipples installed in "E" loop after increasing the chlorination and phosphate levels as described in the previous report[14] were determined. After 33 days' service the rates were:

Copper Supply	0.11 mil per year
Copper Return	0.12 " " "

These rates were considered satisfactory.

The attached curves indicate that the average corrosion rate as determined by test nipples will not, by itself, give the whole corrosion picture. It is apparent now that serious pitting can occur even with a low average corrosion rate. However, the objectionable copper pitting in "E" loop was evident in the test nipples long before the test condensers showed pitting; so they do serve some purpose in addition to giving the average corrosion rate.

K-31, K-33 Cathodic Protection System

A contract was awarded to Vickers Construction Company for the installation of a cathodic protection system for the underground recirculating water lines serving K-31 and K-33. Construction work was begun in May and as of the end of this report period was approximately 75 per cent complete.

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[14] C. C. Fowlkes and J. L. Gamble, Summary of Recirculating Water Treatment Tests for March and April, 1957, Process Utilities Department, UCNC, Oak Ridge Gaseous Diffusion Plant, July 25, 1957, (KP-570, Part 22).

K-892 Test Loop

The K-892 test loop was returned to service using the Betz Dianodic treatment, Orocol No. 181, with 20 ppm chromate and 20 ppm phosphate. The previous K-33 water treatment is being simulated as closely as possible. This test is being run while awaiting completion of the Clinch River make-up pumping station to determine the confidence with which test loop results can be projected into a large operating water system.

Mercury Reduction in K-892 Infilco Accelators

A one-week test to determine the efficiency of the K-892 Infilco Accelators in removing mercury from the make-up water was made.[15] The results of this test showed an average of 51 per cent removal of the mercury by the coagulation process.

Meeting with Dearborn Chemical Company

A meeting was held on May 9, 1957 with Dearborn Chemical Company representatives regarding recirculating water treatment at ORGDP.[16] At this meeting the Dearborn representatives described their answer to our copper corrosion problem, which, in brief, consists of raising the recirculating water pH above 6.7, allowing the formation of a natural copper oxide protective coating, and the addition of a special polyacrylate dispersive agent to prevent excessive deposition and loss of heat transfer. They admitted that this treatment is still in an experimental stage and that they have intensive tests in progress. It was agreed that their approach seemed promising and that, if possible, we would perform a test of their treatment in our K-892 recirculating water test loop, probably sometime this fall.

Tests and operating results of the individual loops are as follows:

A Loop (K-25 East) and B Loop (K-25 West)

The combined "A" and "B" loop pumpages increased from 54 to 61 million gallons per day--an exact reversal of last period's decrease in pumpage requirements. There were no other indications of loss of heat transfer, as the "A" loop return water temperature increased 1.5° F to 122° F and the average water control valve position, as indicated in K-309-2, closed

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[15] L. L. Anthony, Process Utilities Progress Report, Week Ending May 19, 1957, May 20, 1957.

[16] C. C. Fowlkes, Minutes of Meeting with Dearborn Chemical Company Representatives Regarding Recirculating Water Treatment at ORGDP, May 9, 1957, written May 16, 1957.

from 46 to 45 per cent open. For "B" loop, the return water temperature was constant, and the average water control valve position, as indicated in K-304-4, decreased from 39 to 37.5 per cent open.

C Loop (K-27/K-29)

The "C" loop recirculating water treatment changes which were made on June 11, 1957 have been discussed previously in this report.

Total pumpage requirements increased from 58.5 to 65 million gallons per day, but this increase is believed to be due mainly to an unusually high supply water temperature at the end of June. The K-27 water control valves, as indicated in K-402-3, averaged closing from 63 to 60 per cent open by June 29, but opened to 70 per cent on June 30 due to the abnormally high (87.7° F average) supply temperature. The K-29 water control valves, as indicated in K-502-1, averaged opening from 42 to 45 per cent open during this report period. The "C" loop return water temperature increased 1° F to 121° F.

There were no K-29 condenser failures during this report period.

E Loop (K-31)

The "E" loop recirculating water treatment changes which were made on June 11, 1957 were thoroughly covered earlier in this report.

There was no significant change in heat transfer characteristics, as the return water temperature, pumpage requirements and the average water control valve position, as indicated in K-602-3, was unchanged.

There were no condenser failures during this report period. Several condensers were changed out in connection with the ALC program. Following Probolcg tests, most of these condensers were retubed without acid cleaning. One condenser (no. 219012 from K-602-2.6) was acid cleaned and had 53 tube leaks. It was also retubed before installation in K-602-3.1.

G Loop (K-33)

The "G" loop recirculating water treatment changes which were made on June 11, 1957 have been previously discussed.

Pumpage requirements increased from 237 to 252 million gallons per day as a result of converting 10 cells for the ALC program. This also resulted in a return water temperature drop from 147.5° F to 145.5° F. The average water control valve position, as indicated in K-902-4, opened from 64 to 68 per cent open.

There were no condenser failures during this report period.

Monthly Average Water Analyses

Attached are separate water analyses sheets for May and June, 1957.

The soluble copper concentration in "G" loop, while still a little high, showed a decrease in May. For June, only the total copper concentration is available, but this value shows a decrease from May.

The calcium hardness and total dissolved solids in the make-up water showed a decided increase from previous months, and this increase is reflected in the recirculating water analyses. The "G" loop average calcium hardness of 276 ppm for May and 271 ppm for June were very close to the control point of 280 ppm allowable calcium hardness. As individual analyses showed as high as 316 ppm calcium hardness, these high hardness values may have contributed to the loss of heat transfer experienced in "G" loop during this period.

The "G" loop total treatment costs for June show an appreciable drop due to adoption of a less expensive recirculating water treatment. On June 11, 1957, the treatment was changed from Orocol No. 181H to Orocol No. 179H; and, as the No. 179H had to be temporarily made from a mixture of Orocol No. 181H and Calgon, an additional savings was effected.

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Approved: L. L. Anthony
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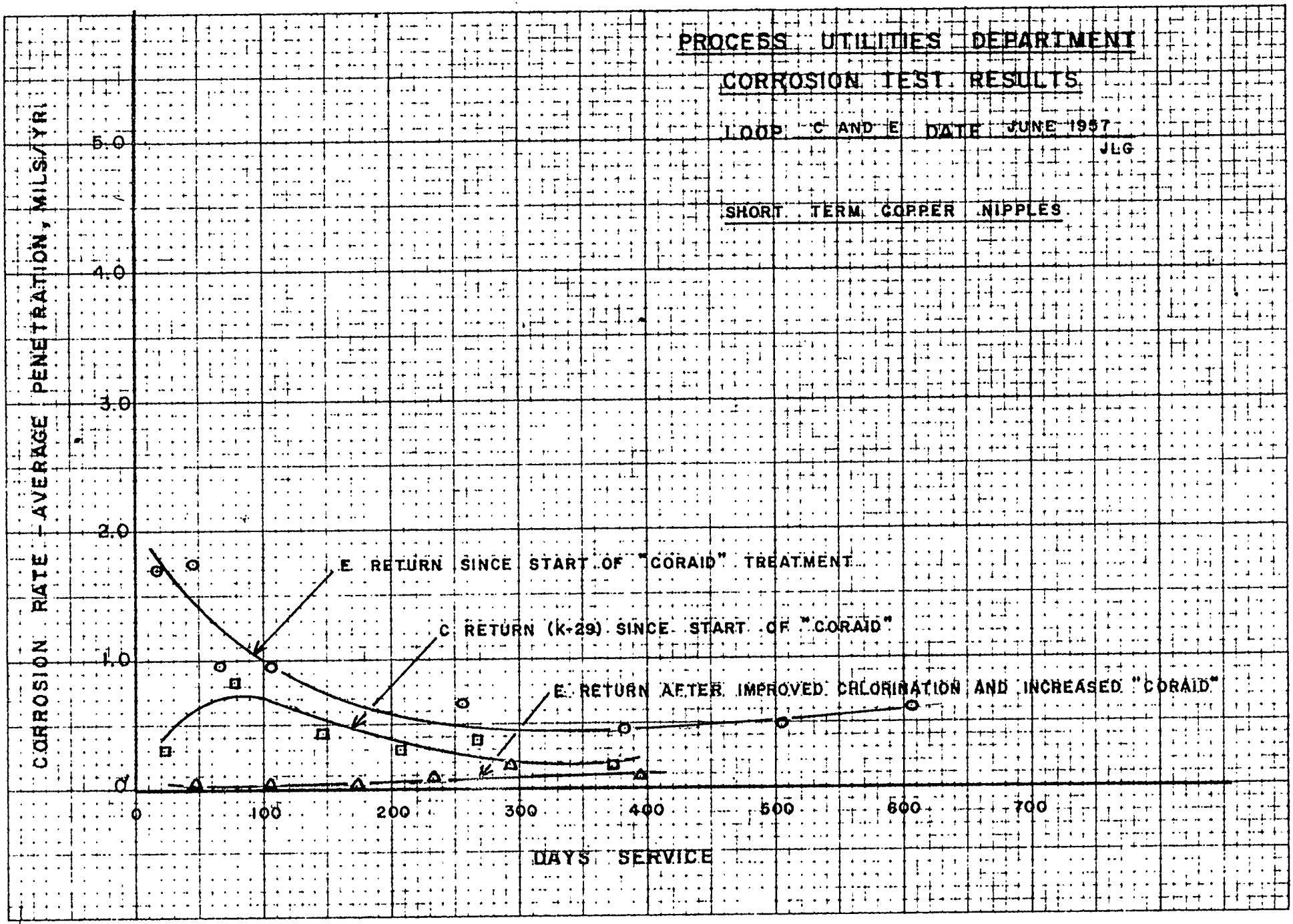

FIGURE 1

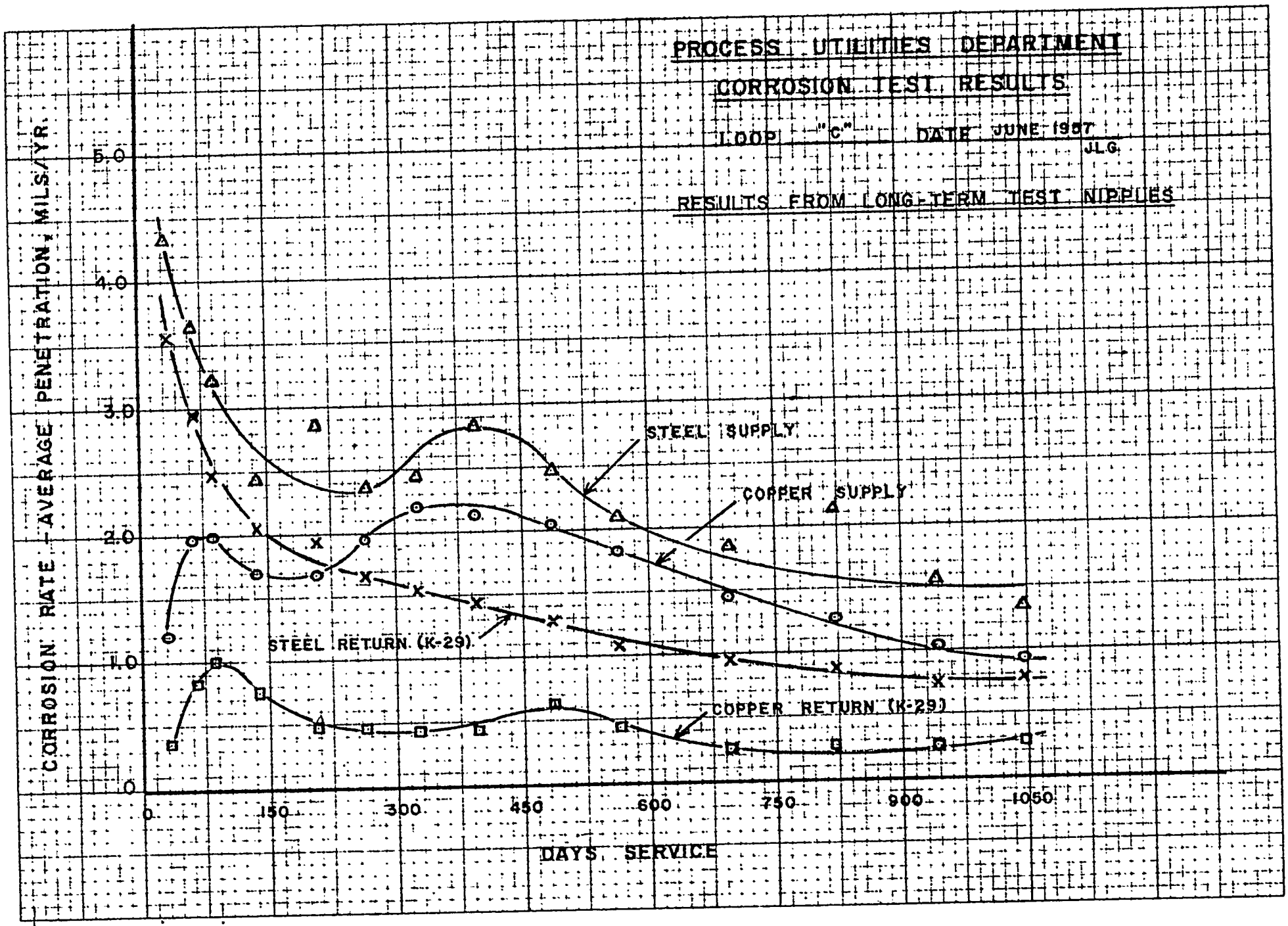

FIGURE 2

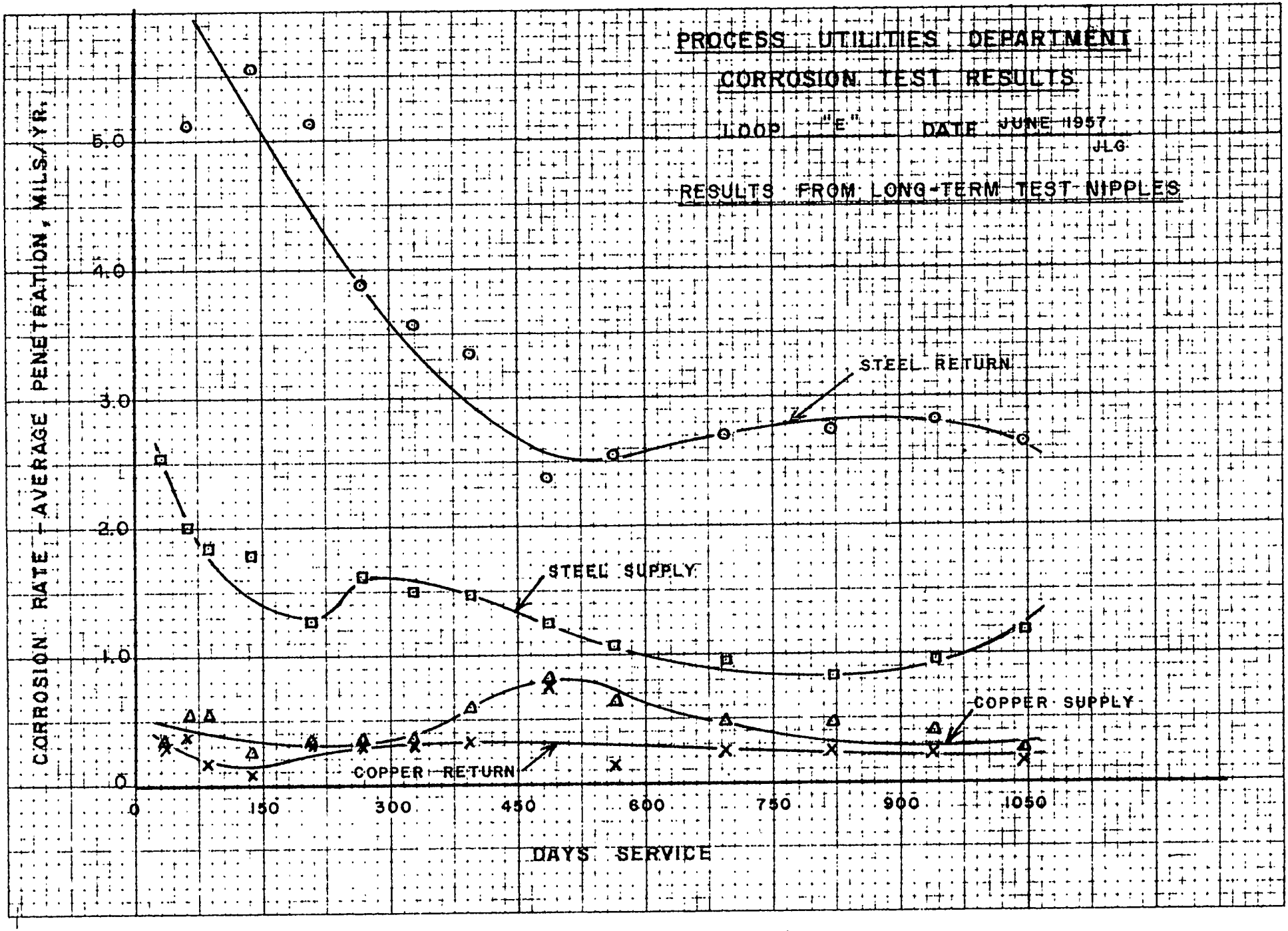

FIGURE 3

MONTHLY AVERAGE WATER ANALYSES - MAY, 1957

P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	237	245	238	454	451	638	760	881
Metaphosphate as $NaPO_3$	0.22	0.35	0.15	6.23	5.84	10.17	8.06	6.05
Orthophosphate as $NaPO_3$	0.55	0.79	0.17	8.40	7.42	6.36	9.22	11.91
Total Hardness as $CaCO_3$	146	141	138	210	202	301	356	417
Calcium as $CaCO_3$	91	103	95	130	124	189	221	276
M-Alkalinity as $CaCO_3$	80	79	73	15	21	9	10	11
Turbidity as SiO_2	12.1	11.2	4.7	18.	16	25	25	31
Copper as Cu - Soluble	0.06	0.06	0.05	0.07	0.07	0.08	0.10	0.11
" " " - Total	0.07	0.06	0.06	0.09	0.09	0.09	0.10	0.21
Total Iron as Fe	0.62	0.64	0.55	0.89	0.94	1.32	1.44	2.46
Sulphate as (SO_4)	12	12	12	86	87	133	164	181
Suspended Solids	6.0	5.5	1.6	9.0	7.4	14.0	15.0	18.0
Chromates as CrO_4	-	-	-	-	-	-	-	23.63
Manganese as Mn	0.07	0.06	0.06	0.08	0.08	0.14	0.26	0.07
Zinc as Zn	-	-	-	-	-	1.63	1.63	-
pH	7.88	7.89	7.48	6.80	6.79	6.05	6.03	6.08
Recirculating Water Treatment Used	-	-	-	Calgon		Calgon-Coraid	Calgon-Coraid	Betz Dianodic
Total Chemical Treatment Costs per Million Gallons of Water Recirculated	-	-	-	$0.626		$1.638	$2.541	$1.880
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-		5.25	6.14	5.06

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - JUNE, 1957

P.P.M.	POPLAR CREEK	K-801-A	K-891	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	176	183	259	468	459	595	743	764
Metaphosphate as $NaPO_3$	0.27	0.85	0.13	5.82	5.37	7.40	7.52	6.29
Orthophosphate as $NaPO_3$	0.47	0.72	0.14	8.19	7.79	5.87	10.02	11.59
Total Hardness as $CaCO_3$	145	153	152	244	249	337	377	416
Calcium as $CaCO_3$	98	98	93	162	154	222	238	271
M-Alkalinity as $CaCO_3$	67	61	56	14	14	8	9	12
Turbidity as SiO_2	68.8	15.7	7.5	29	28	44	38	48
Copper as Cu - Total	0.10	0.11	0.08	0.13	0.13	0.16	0.12	0.17
Total Iron as Fe	0.45	0.55	0.60	0.81	0.79	1.18	1.28	1.19
Sulphate as (SO_4)	35	39	37	81	83	96	100	103
Suspended Solids	22.0	7.0	2.5	19	16	33	24	35
Chromates as CrO_4	-	-	-	-	-	16.34**	19.23**	18.95
Manganese as Mn	0.05	0.05	0.05	0.07	0.07	0.12	0.19	0.05
Zinc as Zn	-	-	-	-	-	1.01	1.08	-
pH	7.31	6.86	6.90	6.76	6.79	6.01	5.99	6.07
Recirculating Water Treatment Used	-	-	-	Calgon		*	*	Betz Dianodic
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$1.016		$1.816	$2.202	$1.664
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-		6.26	5.41	4.82

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

*On June 11, Calgon-Coraid treatment was discontinued, and Betz Dianodic started.
**After June 11, 1957

Date of Issue: October 16, 1957

Report Number: KP-570
Part No. 24

SUMMARY OF RECIRCULATING WATER TREATMENT TESTS FOR JULY AND AUGUST, 1957

C. C. Fowlkes and J. L. Gamble

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OAK RIDGE GASEOUS DIFFUSION PLANT
Production Division
Process Utilities Department

INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

A Division of Union Carbide and Carbon Corporation

To: Mr. H. G. P. Snyder
K-303-7

Plant: ORGDP

Date: October 16, 1957

Copies To: Attached Distribution

Subject: Summary of Recirculating Water Treatment Tests for July and August, 1957

KP-570, Part No. 24

Summary

This report outlines the operating results of all recirculating water systems and the results of corrosion investigations during July and August, 1957. Included are corrosion curves for the K-27, K-29, K-31 and K-33 recirculating water systems, and a discussion of initial softening operation of Clinch River make-up water.

Freon Condenser Corrosion Investigations

The more significant developments concerning the freon condenser corrosion problem were:

1. Three standard copper degreased tubes were examined after 98 days' exposure in the K-801-A test loop.[1] During this period, a simulated Nalco 33 water treatment was tested using sanitary water adjusted to a pH of 6.2 and treated with Calgon and ferrocyanide. All the tubes had a tan, powdery scale about 0.015 inch thick over a thin, greenish yellow subscale. Practically the entire tube surface was attacked slightly, there were small areas of moderate attack in each tube; however, no pits were found. Replacement tubes representative of the original tubes which had pitted badly in the Paducah freon condensers were installed in the test condenser, and the same test was repeated.

   Two of the Paducah-type tubes and one standard copper degreased tube were examined after 78 days.[2] None of the tubes were pitted, but the two Paducah tubes had slightly more severe surface attack than the degreased tube, and patches of green deposits over cuprous oxide were noted on the tube surface. The unexposed section of one of these tubes had a heavy black deposit on the surface while the other had a light gray, oily-appearing surface film.

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[1] Technical Division Weekly Report for the Week Ending July 12, 1957, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, July 15, 1957, (KLI-4145, Part 3). (Secret)

[2] Technical Division Weekly Report for the Week Ending August 30, 1957, (KLI-4145, Part 10). (Secret)

2. Metallurgical examinations were made on three standard copper degreased tubes removed from the test condenser in the K-33 return water system.[3] Two of the tubes had 203 days' service and the other had 504 days' service. All of the tubes had a very thin, gray surface scale, and the tube with 504 days' service had a thin, black film of subscale. The presence of mercury was suspected in one of the tubes (203 days) when silvery areas appeared on the surface after cleaning. These areas would then disappear in about 15 minutes. Vapor detector tests on each tube showed the presence of mercury and quantitative spectrographic analysis of the scale from one of the tubes showed 0.1 per cent mercury. Despite the presence of mercury, there was no pitting in the tubes and the surface attack was only mild. Qualitative tests have previously shown mercury in the scales from both K-33 and K-31 test condenser tubes, but this is the first instance of visible mercury on the tube surface.

3. During this report period a total of six K-31 freon condensers were examined with the Probolog. All of these were original installations and all were found to be severely pitted. Two of these condensers were acid cleaned to confirm the Probolog data; 107 leaking tubes were found in one condenser and 44 leaking tubes were found in the other. No known leaks existed in any of the condensers prior to removal from service. All were sent to Goslin-Birmingham for retubing.

K-31--K-33 Cathodic Protection System

The lump-sum subcontractor has completed the installation of the cathodic protection system for protection of the underground recirculating water lines serving K-31 and K-33. The system has been energized, and UCNC forces are presently testing the system and will adjust all voltages and current flows to obtain the proper protection.

Steel and Copper Corrosion Rates

A corrosion meter for determining steel and copper corrosion rates by measuring resistance changes in special probes inserted in the recirculating water systems was obtained and probes were installed in all recirculating water loops. Test nipples were also installed for correlating the Corrosometer data.[4] Preliminary results from the Corrosometer are very encouraging. These results, together with the associated test nipple results, are illustrated on the attached curves, Figures 1 through 3. While the individual readings at any given time are not comparable, it will be noted that the average values as determined by the Corrosometer

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[3] Ibid.

[4] J. L. Gamble, Progress Report, Corrosion Control and Engineering, Report No. 8, July 19, 1957.

agree very well with the values determined by the test nipples. If satisfactory results continue to occur, the Corrosometer will replace much of the present test nipple work.

Figure 4 illustrates the results of corrosion tests on "G" loop since the start of Orocol 179 treatment as determined by the Corrosometer. Test nipple data are not available for comparison.

Make-up Water Treatment

The source of make-up water was changed from Poplar Creek to Clinch River on July 1, 1957. Chemical treatment for the Infilco accelators was changed at this time from coagulation to cold lime softening.

Initial operating conditions were erratic and several changes to the equipment were required. Good operational control was accomplished from alterations to the chemical feeders, slaking tanks, feed lines and exhaust system.

The type of lime material now being used has contributed greatly to the present controlled conditions. It is a dust-free one eighth-inch to three eighths-inch pebble quicklime. Pulverized lime was difficult to use due to flooding and arching in the feeders and hoppers.

New chemical-handling facilities, specially designed for slaking quicklime, will be placed in service during the first quarter of 1958.

The hardness of the effluent can be reduced between 35 and 40 per cent with a treatment of 50 ppm lime and 15 ppm ferric sulphate. Extensive laboratory testing indicates that the new coagulant aids are of no benefit to the treatment during normal raw water conditions. Materials showing promise of increasing operating efficiency will be investigated by plant trials.

Tests and operating results of the individual loops are as follows:

A Loop (K-25 East) and B Loop (K-25 West)

The combined "A" and "B" loop pumpages decreased from 61 to 52 million gallons per day, reversing the trend of the last report period. The "A" loop return water temperature increased 1° F to 123° F, and the average water control valve position, as indicated in K-309-2, closed from 45 to 44 per cent open. For "B" the return water temperature was constant, and the average water control valve position, as indicated in K-304-4, decreased from 37.5 to 35 per cent open.

C Loop (K-27/K-29)

The "C" loop total pumpage requirements decreased from 65 to 42 million

gallons per day, and the return water temperature increased from 121° F to 132° F. These changes were mainly due to the K-27 power load drop of 12.8 per cent, and to an increased coolant temperature (127° F to 153° F) to the K-27 coolers. The K-27 water control valves, as indicated in K-402-3, average closing from 60 to 47.5 per cent open. The K-29 water control valves, as indicated in K-502-1, averaged opening from 45 to 54 per cent during this report period.

E Loop (K-31)

During this period there were no significant changes in either the "E" loop pumpage requirements or in the return water temperature. However, the water control valves as measured in K-602-3 averaged closing from 45 to 36 per cent open, and this change is attributed to replacement of five condensers in this building within this report period in connection with the ALC program.

G Loop (K-33)

Due to a power load decrease of 8.7 per cent, the "G" loop pumpage requirements dropped from 252 to 222 million gallons per day, and the average water control valve position, as indicated in K-902-4, closed from 67.5 to 58 per cent open. The return water temperature increased 2.5° F to 148° F.

Monthly Average Water Analyses

Attached are separate water analyses sheets for July and August, 1957.

It will be noted that the calcium hardnesses of "E" and "G" loops are much lower than normal, as a result of partial softening of the make-up water. Softened make-up water was supplied to "C" loop starting July 26. The August water analyses for "C" loop show a sharp drop in dissolved solids as well as calcium and total hardnesses as compared to the July analyses.

The economical advantages of partial softening are apparent in the lowered total chemical treatment costs of "E" and "G" loops, as higher concentration ratios allowed reductions in recirculating water treatment costs that more than offset increased make-up water costs. However, "C" loop treatment costs increased in August with softened water, as nonreturn usage prevented higher concentration ratios and the increased treatment costs are due to higher make-up water costs. Investigations are now being made to reduce "C" loop nonreturn usage where economically feasible.

C. C. Fowlkes
C. C. Fowlkes

Approved: W. C. Hartman
W. C. Hartman
Process Utilities Department

J. L. Gamble
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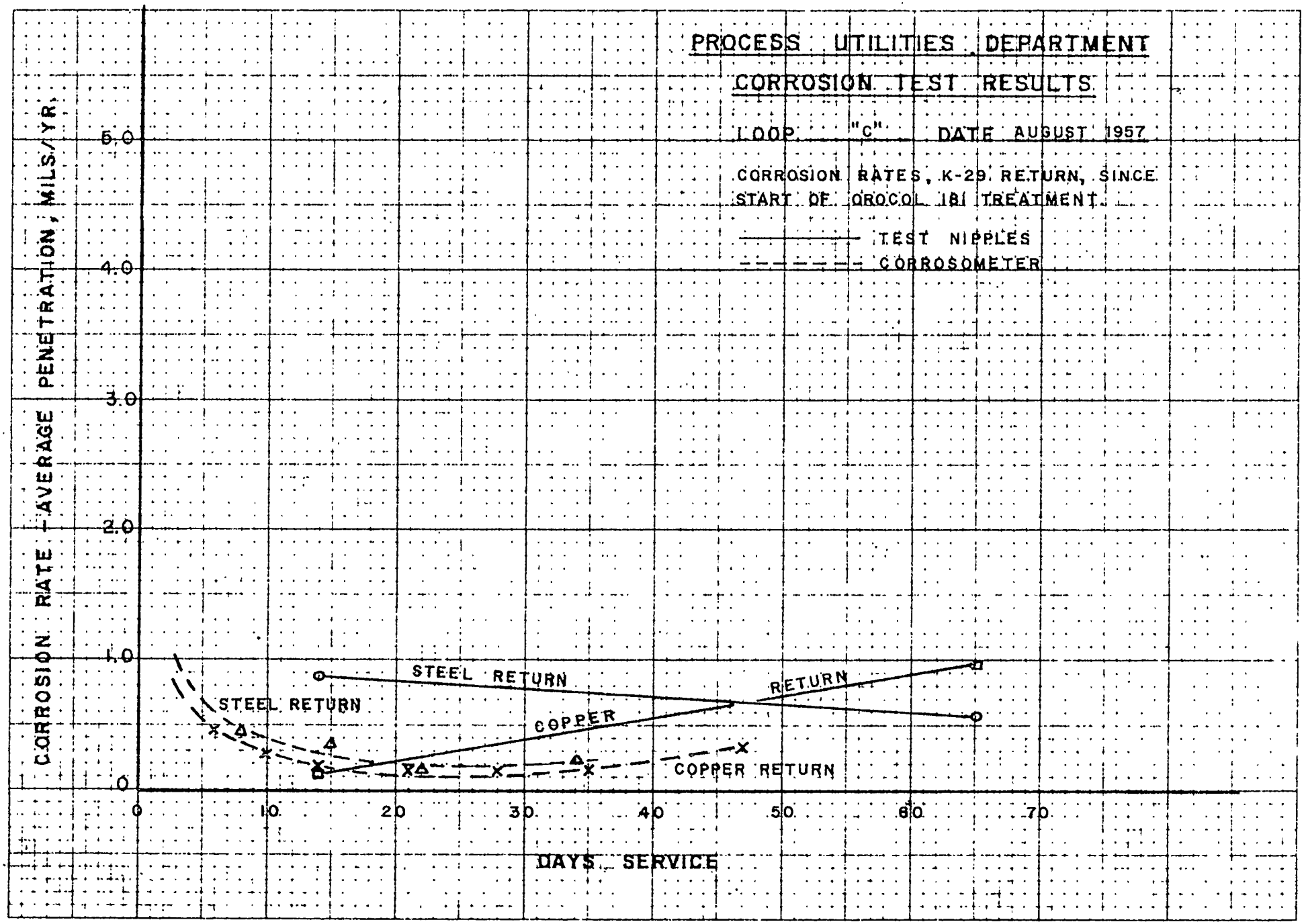

FIG. 1

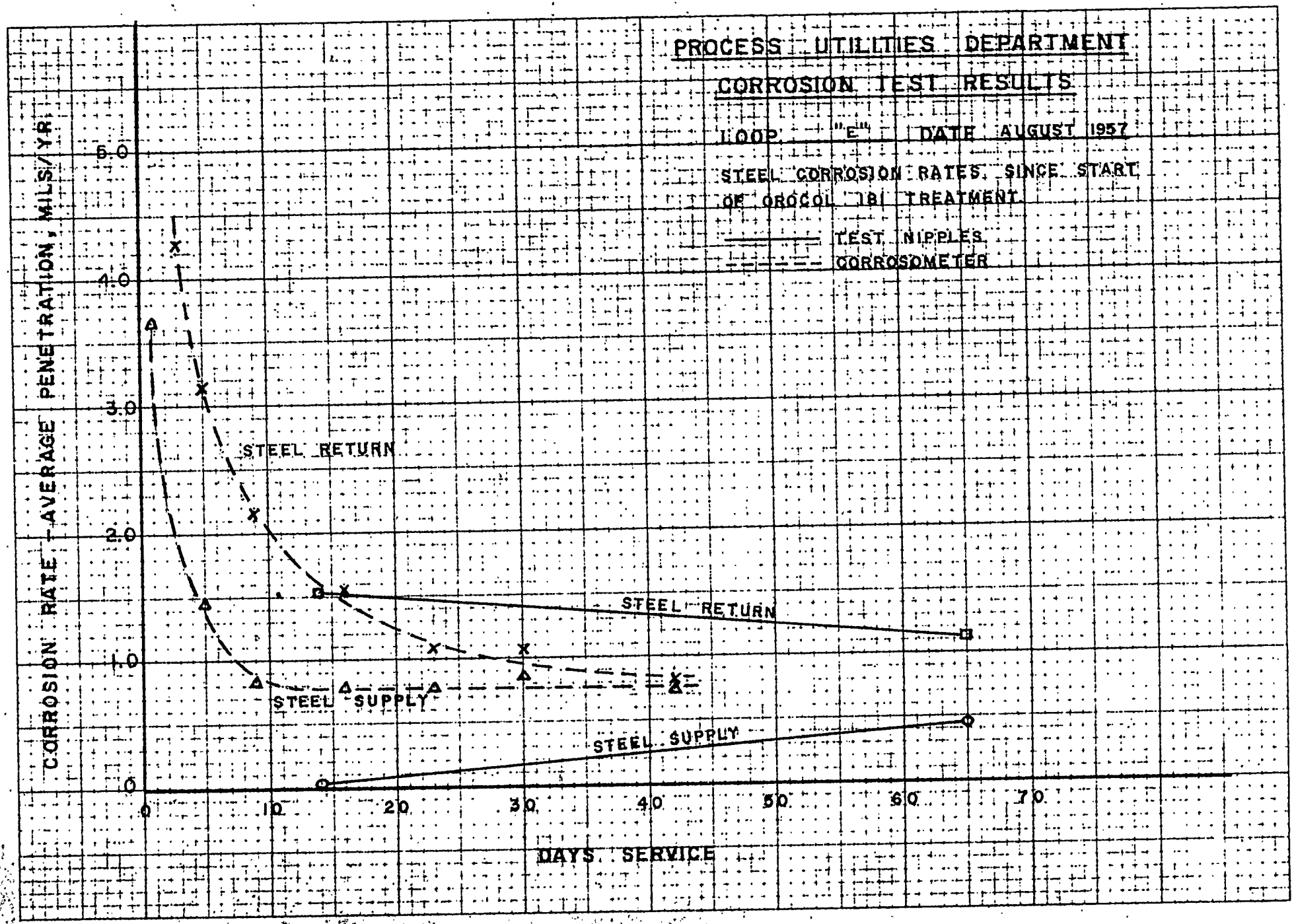

FIG. 2

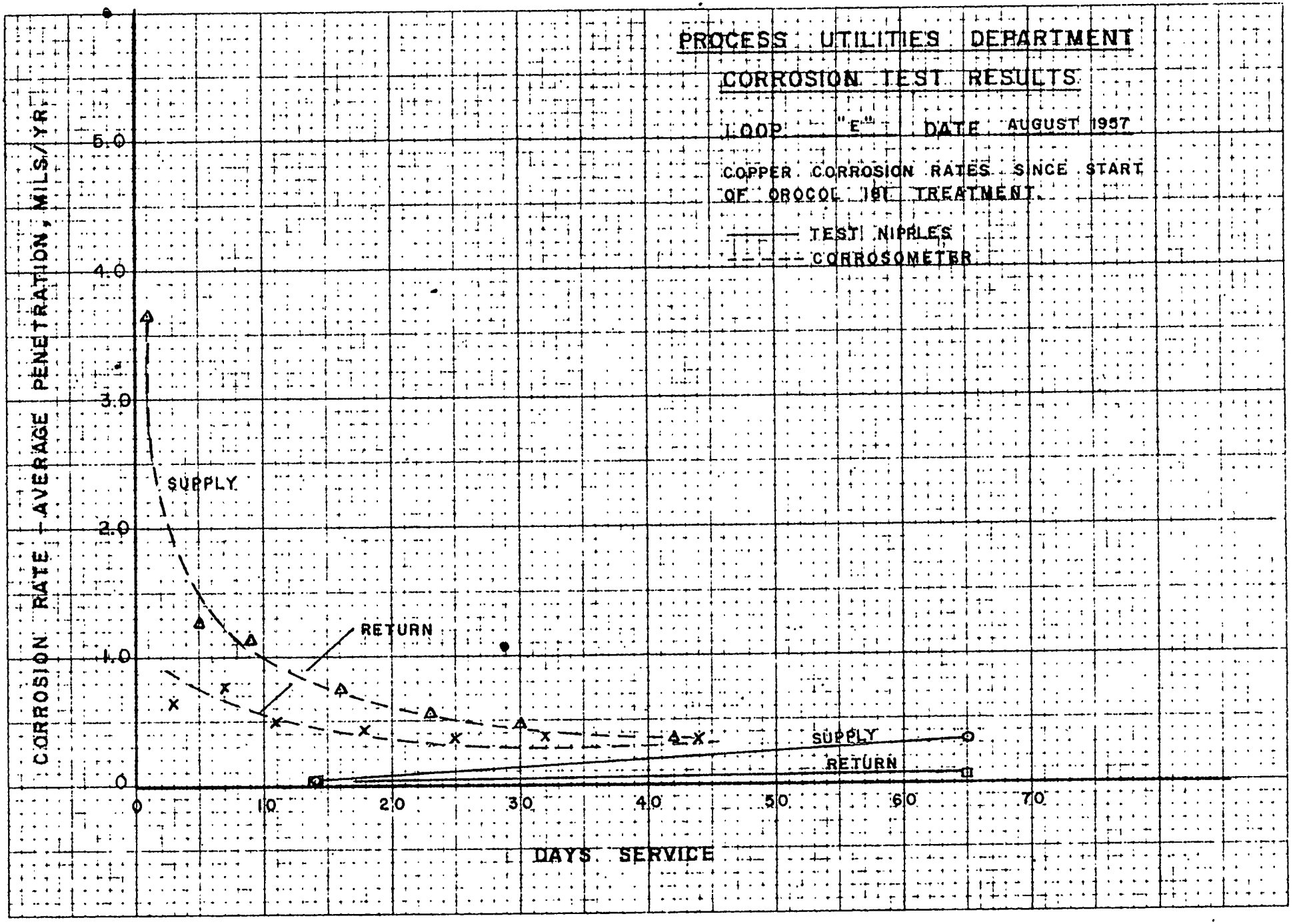

FIG. 3

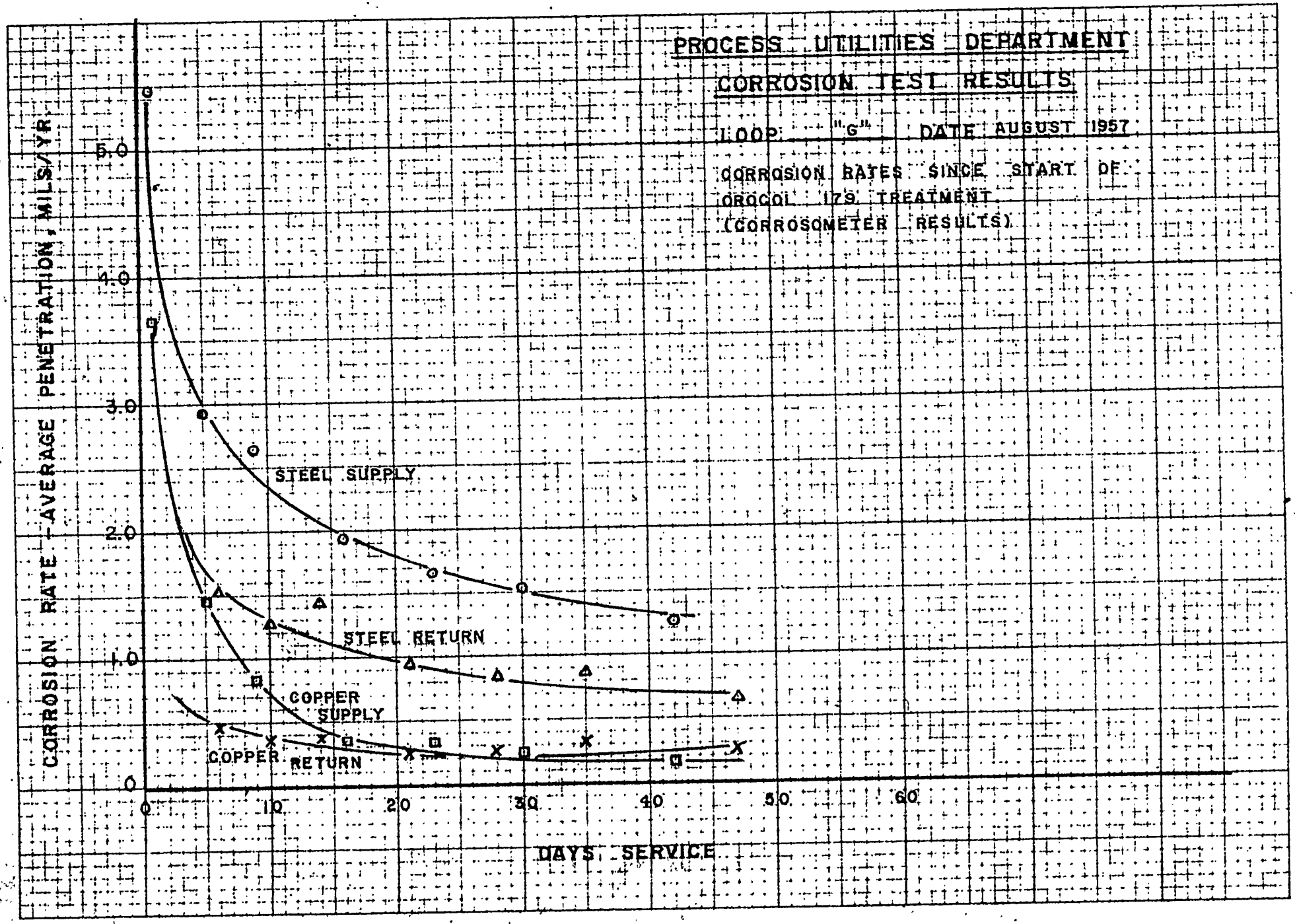

FIG. 4

MONTHLY AVERAGE WATER ANALYSES - JULY, 1957

P.P.M.	Clinch River	P.C. & K-801-A	K-891	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	149	214	163	378	401	637	448	496
Metaphosphate as $NaPO_3$	0.17	0.11	0.16	5.49	5.17	6.95	6.92	7.42
Orthophosphate as $NaPO_3$	0.10	1.17	0.21	7.78	7.99	9.60	9.62	14.21
Total Hardness as $CaCO_3$	114	143	93	205	206	312	249	310
Calcium as $CaCO_3$	83	94	43	130	135	208	147	174
M-Alkalinity as $CaCO_3$	83	71	44	20	19	11	10	10
Turbidity as SiO_2	22	12	7	24	22	38	22	29
Copper as Cu - Soluble	0.02	0.05	0.05	0.06	0.06	0.06	0.07	0.08
" " " - Total	0.05	0.07	0.06	0.16	0.16	0.26	0.18	0.16
Total Iron as Fe	0.22	0.41	0.21	0.55	0.66	0.83	0.61	0.92
Sulphate as (SO_4)	7	38	13	95	99	183	107	143
Suspended Solids	13	14	4	16	17	27	17	24
Chromates as CrO_4	-	-	-	-	-	14.7	16.3	10.1
Manganese as Mn	0.03	0.03	0.03	0.05	0.05	0.10	0.07	0.03
Zinc as Zn	-	-	-	-	-	0.38	0.49	-
pH	8.08	7.99	9.09	6.78	6.78	6.01	6.01	6.17
Recirculating Water Treatment Used	-	-	-	Calgon		Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.742		$1.644	$1.831	$1.409
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-.		4.55	4.54	4.06

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - AUGUST, 1957

P.P.M.	Clinch River	P.C. & K-801-A	K-891	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	120	172	96	334	321	331	452	520
Metaphosphate as $NaPO_3$	0.10	0.22	0.10	6.60	6.39	10.76	7.26	5.33
Orthophosphate as $NaPO_3$	0.10	0.95	0.11	6.53	6.95	8.04	11.07	14.53
Total Hardness as $CaCO_3$	118	110	70	166	167	184	261	305
Calcium as $CaCO_3$	76	65	38	101	99	102	151	180
M-Alkalinity as $CaCO_3$	88	70	43	22	23	10	9	10
Turbidity as SiO_2	13.0	23.0	6.3	39	35	7	17	19
Copper as Cu - Soluble	0.04	0.06	0.04	0.06	0.06	0.06	0.07	0.07
" " " - Total	0.04	0.11	0.05	0.10	0.09	0.16	0.18	0.27
Total Iron as Fe	0.24	0.39	0.14	0.31	0.32	0.37	0.55	0.65
Sulphate as (SO_4)	6	6	5	88	99	132	216	245
Suspended Solids	8	12	14	26	23	5	13	15
Chromates as CrO_4	-	-	-	-	-	15.4	17.1	9.7
Manganese as Mn	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06
Zinc as Zn	-	-	-	-	-	0.28	0.49	-
pH	7.96	7.82	9.20	6.78	6.81	6.00	6.00	6.17
Recirculating Water Treatment Used	-	-	-	Calgon		Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$1.161		$2.230	$1.614	$1.331
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-		6.08	4.14	3.83

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

Date of Issue: January 16, 1958

Report Number: KP-570
Part No. 25

Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, Operating Contractor for the U.S. Atomic Energy Commission.

SUMMARY OF RECIRCULATING WATER TREATMENT TESTS FOR SEPTEMBER AND OCTOBER, 1957

C. C. Fowlkes and J. L. Gamble

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OAK RIDGE GASEOUS DIFFUSION PLANT
Production Division
Process Utilities Department

INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

A Division of Union Carbide and Carbon Corporation

To: Mr. H. G. P. Snyder
K-303-7

Plant: ORGDP

Date: January 16, 1958

Copies To: Attached Distribution

Subject: Summary of Recirculating Water Treatment Tests for September and October, 1957

KP-570, Part No. 25

Summary

This report describes the results of all recirculating water treatment and corrosion tests and outlines the operating results of all recirculating water systems during September and October, 1957.

Freon Condenser Corrosion Investigations

The more significant developments concerning the freon condenser corrosion problem were:

1. Six tubes from the steam-heated test condenser in the K-29 recirculating water supply system were examined after exposure periods of 75 to 588 days.[1] Water treatment during this period included Betz Dianodic for the last 90 days, Calgon-Coraid for the previous 372 days, and Calgon "T" at the start of the period. Poplar Creek make-up water was used except for the last 60 days when softened Clinch River make-up was used. Examination of the tubes exposed to only the Betz Dianodic treatment revealed no pits and only slight surface attack. One tube with 588 days' service had no pits but slightly more severe surface attack. The remaining three tubes exposed to both the Calgon and the Betz treatment were pitted and had areas of severe surface attack. Small tubercles were found on two tubes, none on the others. The absence of tubercles may indicate that the Betz treatment is removing the corrosion products and may eventually passivate the presently active pits. Nearly all the pitted tubes and several of the unpitted tubes removed previously from this test condenser have contained numerous tubercles.

2. After mercury was detected in a tube from the test condenser in the K-33 return water system,[2] several of the tubes removed from

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[1] Technical Division Weekly Report for the Week Ending October 25, 1957, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, October 28, 1957, (KLI-4145, Part 18). (Secret)

[2] C. C. Fowlkes and J. L. Gamble, Summary of Recirculating Water Treatment Tests for July and August, 1957, Process Utilities Department, UCNC, Oak Ridge Gaseous Diffusion Plant, October 16, 1957, (KP-570, Part 24).

other condensers since that time have been checked for mercury.[3] Tubes from the K-31 supply and return condensers exposed only to the Betz treatment and Clinch River make-up water were found to contain essentially the same quantity of mercury in the scale (300 to 500 ppm) as tubes exposed to Calgon treatment and Poplar Creek make-up. This may indicate redistribution of the mercury previously deposited; and if this mercury is responsible for the copper corrosion, it may mean continued corrosion potential for some time even with Clinch River make-up. However, the Betz treatment has apparently been successful in inhibiting the mercury effects.

Probolog Operations

A total of six condensers removed from service in K-31 during the A-line cooling program were inspected with the Probolog. It was concluded that all six were pitted beyond economical use. One condenser was acid cleaned to confirm the Probolog data, and 169 leaking tubes were found after cleaning. All six condensers were sent to Goslin-Birmingham for retubing, along with one spare used condenser which was inspected and found defective.

Two retubed K-31 condensers were inspected prior to being placed in service for comparison with future inspections. These condensers were installed in K-602-1.2 and K-602-2.7.

One retubed K-29 condenser was inspected prior to installation in K-502-1.5 for comparison with future inspections.

Corrosion Rates

The use of the Corrosometer for determining steel and copper corrosion rates in the recirculating water systems was adopted as the standard method, and most of the test nipple work has been discontinued. Corrosion rates being obtained at the end of this report period were as follows:

	Mils Per Year		Days' Service
	Steel	Copper	
K-33 Supply	0.80	0.07	98
K-33 Return	0.55	0.20	103
K-31 Supply	0.52	0.19	98
K-31 Return	0.49	0.18	100

Sufficient probes have been ordered to replace the K-29 probes and to extend the tests to the "A" and "B" recirculating water systems.

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[3] Technical Division Weekly Report for the Week Ending November 1, 1957, Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, November 4, 1957, (KLI-4145, Part 19). (Secret)

Test Condenser Program

Responsibility for operation of the steam-heated test condensers in K-29, K-31, and K-33 has been transferred to the Process Utilities Department.[4] These test condensers have been set up to duplicate conditions in the freon condensers as closely as possible and will be used as corrosion monitors in each system. Routine inspection with the Probolog will be made to detect any pitting in the tubes, and operating logs will be kept as a record of heat transfer conditions. Tubing installed in the test condensers is identical to that in the process freon condensers.

A Loop Corrosion Inspection

Sections of four-inch steel pipe were removed from the supply and return lines in K-309-2 for inspection to determine the internal conditions of the system.[5]

These lines had been in almost continuous service since start-up of K-25 and are assumed to be representative of all the steel lines in "A" loop. Inspection revealed a moderate coating of what appeared to be calcium phosphate and/or calcium carbonate, somewhat heavier on the return line, over a thin layer of iron oxide. Corrosion penetration was negligible on the supply line and less than 20 per cent of the wall thickness on the return line with only moderate pitting. Based on these inspections, it appears that internally the steel lines in "A" loop are in fairly good condition and that satisfactory corrosion control exists. The treatment in this system is straight polyphosphate.

External Corrosion, K-25 Recirculating Water Lines

The pipe-to-soil potential tests and spot inspections to determine the external condition of the underground recirculating water lines serving K-25 have been completed.[6] From the results of these inspections it was concluded that the extent of corrosion on these lines does not indicate immediate danger and that, at present, no program of corrosion control is necessary. A few locations of moderate corrosion were found, primarily at locations where poor coating of the lines existed. These locations were recoated with coal tar enamel. Spot applications of cathodic protection may be considered at a later date should trouble arise in any of the affected areas.

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[4] J. L. Gamble, Progress Report, Corrosion Control and Engineering, Report No. 11, UCNC, Oak Ridge Gaseous Diffusion Plant, October 8, 1957.

[5] Ibid.

[6] F. A. Lehmann, letter to W. C. Hartman, entitled "ESO M-22033 Completion Report," dated September 25, 1957.

K-892 Test Loop

The K-892 test loop was shut down after four months of the Betz Orocol 181 test. This test had been run to establish the degree of confidence with which test loop results can be projected into an operating system and was an interim test while awaiting softened Clinch River water for make-up. During the first part of the test, good agreement with "G" loop results was obtained. Later, due to erratic test loop control, results from the test loop also became erratic.

However, heat transfer conditions remained good throughout the test, and a Probolog inspection of the test condenser tubes revealed no pitting. Destructive examination of two of the tubes from the test condenser confirmed these results.

After consistent results were obtained on softening operations at K-892, a new test was started. This is a low phosphate--high pH treatment, which has not been tried here at the high temperatures involved. This treatment uses Calgon "T" at 2.0 ppm metaphosphate and 7.7 pH. This is planned as a long-term test, probably at least six months if the expected results are obtained. Should difficulty arise regarding heat transfer, which could very well happen at the higher pH value, some sort of sludge dispersal agent may be considered.

A Loop (K-25 East) and B Loop (K-25 West)

The combined "A" and "B" loop pumpages decreased from 52 to 45 million gallons per day, due mainly to power reductions associated with operating difficulties at the K-25 Power Station. The "A" loop return water temperature decreased 1° to 122° F, and the average water control valve position, as indicated in K-309-2, closed from 44 to 43 per cent open. The "B" loop return water temperature dropped 2° to 105° F, and the average water control valve position, as indicated in K-304-4, increased from 36 to 40 per cent open.

Recommendations[7] for corrosion protection to the K-306 section during stand-by conditions have been followed. Briefly, the coolant coolers and the unit recirculating water supply and return headers were purged with dry air and left vented to atmosphere. Protection for the short section of each unit service line from the service valve to the main supply header was accomplished by installation of a blind flange tapped for a one fourth-inch copper tube fitting. The line attached to the blind flange will be continuously flushed with cooling water to provide circulation for corrosion prevention.

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[7]B. R. Webb, letter to G. T. E. Sheldon, entitled "Recommendations for Stand-by Storage of K-306 Coolant Coolers and Recirculating Water Lines," dated September 5, 1957.

C Loop (K-27/K-29)

The "C" loop total pumpage requirements decreased from 42 to 41 million gallons per day, and the return water temperature was constant at 132° F. The K-27 water control valves, as indicated in K-402-3, averaged opening from 47.5 to 54 per cent, and the K-29 water control valves, as indicated in K-502-1, averaged closing from 54 to 52 per cent.

E Loop (K-31)

There were indications of a slight loss in heat transfer characteristics for "E" loop during this report period, as the pumpage requirements increased from 82 to 84 million gallons per day and the return water temperature dropped from 144° to 142° F. The water control valves, as indicated in K-602-3, opened from 36 to 40 per cent.

G Loop (K-33)

There were also indications of some loss of heat transfer characteristics for "G" loop, as the pumpage requirements increased from 220 to 228 million gallons per day with a return water temperature drop of 0.5° to 147.5° F. The water control valves, as indicated in K-902-4, opened from 58 to 63%.

Monthly Average Water Analyses

Attached are separate water analyses sheets for September and October, 1957.

The "E" loop total treatment costs dropped below four mils per million BTU removed as a result of higher concentration ratios being obtained with partial softening of Clinch River make-up water.

C. C. Fowlkes
C. C. Fowlkes

J. L. Gamble
J. L. Gamble

Approved: W. C. Hartman
W. C. Hartman
Process Utilities Department

MONTHLY AVERAGE WATER ANALYSES - SEPTEMBER, 1957

P.P.M.	Clinch River	Poplar Creek	K-891	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	148	72	124	324	324	334	460	636
Metaphosphate as $NaPO_3$	0	0.20	0	6.87	8.32	10.82	7.10	5.22
Orthophosphate as $NaPO_3$	0.06	0.68	0.04	6.35	7.28	7.69	10.55	18.45
Total Hardness as $CaCO_3$	113	70	64	156	158	175	260	362
Calcium as $CaCO_3$	72	48	44	95	96	101	146	210
M-Alkalinity as $CaCO_3$	94	91	39	17	17	8	8	9
Turbidity as SiO_2	32.8	19.5	5.8	20.4	21.7	11.1	14.5	20.2
Copper as Cu - Soluble	0.04	0.05	0.04	0.06	0.06	0.06	0.06	0.09
" " " - Total	0.05	-	0.04	0.08	0.07	0.10	0.10	0.16
Total Iron as Fe	0.13	0.40	0.17	0.39	0.39	0.42	0.48	0.54
Sulphate as (SO_4)	4	6	4	56	59	111	162	223
Suspended Solids	28.4	10.0	5.6	12.6	11.6	5.3	7.5	12.5
Chromates as CrO_4	-	-	-	-	-	16.8	17.9	12.8
Manganese as Mn	0.05	0.07	0.05	0.06	0.06	0.07	0.09	0.06
Zinc as Zn	-	-	-	-	-	0.30	0.39	-
pH	7.66	7.58	9.47	6.78	6.77	6.00	6.00	6.05
Recirculating Water Treatment Used	-	-	-	Calgon		Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$1.119		$2.082	$1.354	$1.205
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-		5.26	3.50	3.49

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - OCTOBER, 1957

P.P.M.	Clinch River	K-891	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	137	92	246	257	340	418	578
Metaphosphate as $NaPO_3$	0	0	7.94	8.61	9.92	6.72	5.25
Orthophosphate as $NaPO_3$	0.08	0.08	7.35	7.75	7.30	8.46	17.34
Total Hardness as $CaCO_3$	115	70	143	131	189	233	334
Calcium as $CaCO_3$	85	41	87	96	101	133	184
M-Alkalinity as $CaCO_3$	94	40	16	16	8	7	8
Turbidity as SiO_2	19.1	3.5	15	16	11	12	15
Copper as Cu - Soluble	0.04	0.04	0.05	0.06	0.06	0.06	0.06
" " " - Total	0.04	0.04	0.08	0.08	0.07	0.10	0.08
Total Iron as Fe	0.12	0.09	0.27	0.27	0.23	0.25	0.36
Sulphate as (SO_4)	5	4	66	70	118	154	223
Suspended Solids	11.0	1.5	6.5	6.6	4.5	4.8	6.2
Chromates as CrO_4	-	-	-	-	17.7	16.5	13.1
Manganese as Mn	0.04	0.04	0.06	0.06	0.06	0.07	0.05
Zinc as Zn	-	-	-	-	0.34	0.30	-
pH	7.61	9.27	6.76	6.75	5.99	5.99	6.06
Recirculating Water Treatment Used	-	-	Calgon		Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$1.155		$2.016	$1.290	$1.127
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-		5.57	3.39	3.26

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

Date of Issue: February 6, 1958

Report Number: KP-570
Part No. 26

METALLURGY

To:

SUMMARY OF RECIRCULATING WATER TREATMENT TESTS FOR NOVEMBER AND DECEMBER, 1957

C. C. Fowlkes and J. L. Gamble

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Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, Operating Contractor for the U.S. Atomic Energy Commission.

INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

A Division of Union Carbide and Carbon Corporation

To: Mr. H. G. P. Snyder
K-303-7

Plant: ORGDP

Date: February 6, 1958

Copies To: Attached Distribution

Subject: Summary of Recirculating Water Treatment Tests for November and December, 1957

KP-570, Part No. 26

Summary

This report describes the results of all recirculating water treatment and corrosion tests and outlines the operating results of all recirculating water systems during November and December, 1957.

Corrosion Investigations

1. Corrosion Rates. Probes for use with the Corrosometer are now in service in all recirculating water loops. Corrosion rates indicated are as follows:

Probe Location	Days' Service	Mils Per Year	
		Copper	Steel
A Loop Supply	7	7.43	3.39
A Loop Return	4	2.97	19.62
C Loop Supply	37	0.049	0.395
C Loop Return (K-29)	37	0.419	0.395
E Loop Supply	135	0.135	0.514
E Loop Return	137	0.127	0.413
G Loop Supply	135	0.053	0.662
G Loop Return	140	0.156	0.456

The corrosion rates for "A" loop are considered somewhat excessive even with the short service time on the probes. Present plans are to confirm these corrosion rates with additional probes and test nipples and possibly examine a K-25 coolant cooler tube bundle.

Corrosion rates on the other recirculating water systems are satisfactory.

2. Probolog Results. During November and December, six K-31 freon condensers which were replaced for the A-line cooling program were inspected with the Probolog. All six were found to be severely pitted. One of these was acid cleaned to confirm the Probolog results, and a total of 66 leaking tubes resulted. All six condensers were from K-602-1 and were sent to Goslin-Birmingham for retubing.

One condenser was removed in K-502-2.4 as the result of freon leakage to the water, and subsequent leak testing revealed two leaking tubes. This condenser was inspected with the Probolog, and, although pitting was

evident throughout the condenser, severe deflections at one point at a baffle location were noted in each of the leaking tubes. The deflections were interpreted to be mechanical damage at those points. The leaking tubes were plugged and the condenser will be used as a spare.

3. K-892 Test Loop. Operation of the K-892 test loop utilizing Calgon, Composition "T," was continued during this report period. During the first month's operation the over-all heat transfer coefficient on the test condenser dropped from 120 to 96 Btu/hr/sq ft/°F, but it has not decreased significantly during the last six weeks of operation. This heat transfer is considered satisfactory. Some deposition was expected at the relatively high pH of 7.7.

   Probes have been obtained for use with the Corrosometer in obtaining corrosion rates for Calgon "T" operation.

4. K-31, K-33 Cathodic Protection. Examination and analysis of anode currents and pipe-to-soil potential tests reported by the Electrical Test Department[1] to the Engineering Department has been completed. Satisfactory protection is being obtained throughout the system except for one area east of the K-892G cooling tower. Plans and cost estimates are being prepared for additional anodes and possibly an additional rectifier for correction to this section.

A Loop (K-25 East) and B Loop (K-25 West)

The combined "A" and "B" loop pumpages decreased from 45 to 40 million gallons per day, due to pressure changes associated with the removal of "B" cooling tower from service, reduced air plant usage, and process operational changes which included raising the stage temperatures to 200° F for seven cells and the elimination of about ten coolant coolers from service.

The changing of the cooler air plant return water to "A" loop from "B" loop resulted in a 3° F drop to 119° F for "A" loop and an increase of 7° to 112° F for "B" loop.

The water control valve positions indicate no significant change in heat transfer characteristics. The average water control valve position, as indicated in K-309-2, opened from 43 to 44 per cent open, and the average water control valve position, as indicated in K-304-4, closed from 40 to 38 per cent open.

C Loop (K-27/K-29)

The "C" loop total pumpage requirements decreased from 41 to 39.5 million gallons per day, and the return water temperature increased from 132 to

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[1] R. A. West, letter to F. A. Lehmann, entitled "K-31, K-33 Cooling Water Cathodic Protection," dated November 19, 1957.

133° F. The K-27 water control valves, as indicated in K-402-3, averaged closing from 54 to 47% open, and the K-29 water control valves, as indicated in K-502-1, averaged closing from 52 to 40% open.

While the K-27 indications of improved heat transfer as noted above could be ascribed to process changes associated with converting seven of the ten K-402-3 cells to the badger cluster arrangement, no reason is known for the K-29 improvement. So, it is possible that continued operation with softened make-up water is responsible for at least part of the improved heat transfer in both K-27 and K-29.

E Loop (K-31)

There were no indications of any change in heat transfer characteristics during this report period.

G Loop (K-33)

There were indications of improved heat transfer for "G" loop during this report period, as pumpage requirements decreased from 228 to 225 million gallons per day; the return water temperature increased 0.5° to 148° F, and the average water control valve position, as indicated in K-902-4, closed from 63 to 61% open.

Monthly Average Water Analyses

Attached are separate water analyses sheets for November and December, 1957.

C. C. Fowlkes

C. C. Fowlkes

J. L. Gamble

J. L. Gamble

Approved: W. C. Hartman

W. C. Hartman
Process Utilities Department

MONTHLY AVERAGE WATER ANALYSES - NOVEMBER, 1957

P.P.M.	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	134	108	232	236	323	444	432
Metaphosphate as $NaPO_3$	0	0	7.43	7.15	9.27	5.11	5.99
Orthophosphate as $NaPO_3$	0.04	0.04	7.48	7.71	8.12	12.90	12.68
Total Hardness as $CaCO_3$	104	74	131	132	192	256	270
Calcium as $CaCO_3$	64	44	82	80	100	139	146
M-Alkalinity as $CaCO_3$	76	41	14	13	8	7	7
Turbidity as SiO_2	51.9	4.8	12	12	12	17	17
Copper as Cu - Soluble	0.05-	0.05-	0.05	0.05	0.05	0.05	0.06
" " " - Total	0.05-	0.05-	0.08	0.08	0.08	0.10	0.14
Total Iron as Fe	0.25	0.10	0.28	0.26	0.28	0.30	0.38
Sulphate as (SO_4)	6	7	73	73	115	177	237
Suspended Solids	39.0	2.7	5.2	5.2	5.4	8.8	8.9
Chromates as CrO_4	-	-	-	-	16.0	16.4	10.0
Manganese as Mn	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Zinc as Zn	-	-	-	-	0.34	0.38	-
pH	7.65	9.27	6.72	6.74	6.00	6.00	6.09
Recirculating Water Treatment Used	-	-	Calgon		Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$1.076		$1.833	$1.303	$1.204
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-		5.10	3.50	3.47

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - DECEMBER, 1957

P.P.M.	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	115	102	210	215	340	466	430
Metaphosphate as $NaPO_3$	0	0	5.85	5.20	8.21	6.69	6.50
Orthophosphate as $NaPO_3$	0.10	0.08	7.29	7.81	9.17	12.70	12.07
Total Hardness as $CaCO_3$	110	88	133	134	209	289	272
Calcium as $CaCO_3$	70	54	84	81	112	147	136
M-Alkalinity as $CaCO_3$	81	49	15	14	8	9	8
Turbidity as SiO_2	38.9	3.8	11	11	8	9	11
Copper as Cu - Soluble	0.05-	0.05-	0.05	0.06	0.05	0.07	0.07
" " " - Total	0.05-	0.05-	0.10	0.10	0.09	0.10	0.16
Total Iron as Fe	0.94	0.27	0.28	0.28	0.30	0.38	0.41
Sulphate as (SO_4)	6	6	56	58	116	192	200
Suspended Solids	76	6	4	4	3	3	4
Chromates as CrO_4	-	-	-	-	15.6	20.5	10.2
Manganese as Mn	0.05-	0.05-	0.05	0.05	0.05	0.05	0.05
Zinc as Zn	-	-	-	-	0.33	0.33	-
pH	7.82	9.57	6.73	6.73	5.99	6.00	6.06
Recirculating Water Treatment Used	-	-	Calgon		Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$0.821		$1.936	$1.435	$1.246
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-		5.16	3.88	3.58

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

Date of Issue: March 25, 1958

Report Number: KP-570
Part No. 27

SUMMARY OF RECIRCULATING WATER TREATMENT TESTS FOR JANUARY AND FEBRUARY, 1958

C. C. Fowlkes and J. L. Gamble

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INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

A Division of Union Carbide and Carbon Corporation

To: Mr. H. G. P. Snyder
K-303-7

Plant: ORGDP

Date: March 25, 1958

Copies To: Attached Distribution

Subject: Summary of Recirculating Water Treatment Tests for January and February, 1958

KP-570, Part No. 27

Summary

This report describes the results of all recirculating water treatment tests and outlines the operating results of all recirculating water systems for January and February, 1958.

Corrosion Investigations

1. Condenser Tube Examinations. Several K-31 freon condensers, retubed by Goslin-Birmingham with tubes produced by Wolverine subsequent to recent improvements in manufacturing techniques, have been examined. Tubes in all except one of the condensers received since Wolverine began using E. F. Houghton Rolling Oil No. 1207 as a lubricant for the production and finning operations have contained no more than light stains resulting from insufficient drying after the wet steam cleaning at Goslin-Birmingham.[1] The acid cleaning and trichloroethylene degreasing steps were omitted in preparing these condensers for service.

   The one exception to the extremely good condition of the recently received condensers contained large quantities of solder and flux in several tubes at the tube sheet ends, as revealed by a Boroscopic examination.[2] A Probolog examination of this condenser indicated the presence of solder and/or corrosion extending almost the entire length of some tubes. Severe stain, and in some instances corrosion, was associated with the flux deposits. This condenser was acid cleaned to remove the deposits.

2. Mercury Analyses. Mercury analyses have been completed on 11 sets of daily spot samples of "C," "E," and "G" loop waters, K-892 A and B effluent, and Clinch River water at the powerhouse inlet.[3] Average values are 2 ppb mercury at the powerhouse inlet and 10 ppb at the K-892 effluent. Eleven, 19, and 14 ppb were found in "C," "E," and "G" loops

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[1] Technical Division Weekly Report, Week Ending January 10, 1958, UCNC, ORGDP, January 13, 1958, (KLI-4145-29). (Secret)

[2] Technical Division Weekly Report, Week Ending February 7, 1958, (KL-1, Part 2). (Secret)

[3] Ibid.

respectively. These values are considerably below those present (70 to 150 ppb) when Poplar Creek was used for make-up.

Qualitative spectrochemical analysis of tube scale from an originally installed K-31 freon condenser, recently removed from service, indicated mercury in concentrations ranging from 100 to 300 ppm.[4] Analysis of scale from a K-25 coolant cooler has shown 300 ppm mercury. Mercury has also been found in water-side scale from powerhouse condensers in concentrations up to 300 ppm.

Continuing analysis for mercury in Clinch River water, recirculating water, and condenser scale is planned to determine the distribution of mercury in the various recirculating water systems as an aid in the evaluation of the effects of Clinch River make-up water.

3. Corrosion Rates. Corrosion rates for "A," "C," "E," and "G" loop recirculating water systems have been determined with the Corrosometer. These corrosion curves are shown in Figures 1, 2, 3, and 4. All are considered satisfactory for the type treatment used in each loop.

4. Test Condenser Inspection. Steam-heated test condensers, simulating conditions in process freon condensers, in K-29, K-31, and K-33 were inspected with the Probolog.[5] The K-29 and K-31 test condensers contain copper tubes ranging from four to eight months' service time. The K-33 test condenser contains tubes ranging from six to nineteen months' service time. No indications of pitting attack were found in any of these condensers.

5. Coolant Cooler Tube Examination. Four sections of copper tubes removed from a coolant cooler in K-302-4 have been examined to evaluate the extent of water-side corrosion.[6] The examination showed that the tubes had suffered some corrosive attack. About 76% of the tube surfaces showed a slight general attack and moderate pitting, about 6% wall penetration, had occurred on about 18% of the area. No previous examination results were available for comparison. The results of this examination appear to bear out the Corrosometer indications of 1.0- to 1.5-mil-per-year copper corrosion rate and to indicate the necessity of a close watch over corrosion control in "A" and "B" recirculating water loops where Poplar Creek water is still the primary source of make-up. It should be noted, however, that this coolant cooler has been in service for 13 to 14 years; thus the total corrosion is not considered serious at this time.

6. K-892 Test Loop Results. A four-month test of Calgon, Composition "TG" was completed. Conditions for this test were:

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[4] Ibid.

[5] W. C. Hartman, Process Utilities Department Operating Summary, Week Ending January 26, 1958, January 27, 1958.

[6] W. S. Dritt and G. L. Marshall to J. L. Gamble, "Coolant Cooler Tubes: Examination of Tube from K-25," February 13, 1958, (KL-27).

Make-up	Clinch River, partially softened
Supply Temperature	105° F
Return Temperature	150° F
Tube Velocity	4 feet/second
pH	7.7
Metaphosphate	2.0 ppm
Concentration Ratio	3:1

Corrosion rates determined by Corrosometer probes inserted in the reservoir are shown on Figure 5. Good protection was obtained on copper and verified by Probolog examination of the test condenser tubes, but practically no protection was obtained on the steel probe--the corrosion rates being about the same as those obtained with no inhibitor on sanitary water. Probolog results of the condenser tubes revealed no pitting.

While very good heat transfer rates had previously been obtained in K-31 at low phosphate--high pH conditions, there was considerable doubt as to the amount of deposition that would be encountered at the higher test temperatures, particularly with a phosphate having a zinc additive. Plans had been made to try a sludge dispersal agent if a scaling problem developed. However, no trouble was experienced with heat transfer throughout the test, and the heat transfer coefficients are shown on Figure 6. It should be noted that the conditions of this test were not recommended by any of the water treating consultants.

A plant-scale test in "A" and "B" loops utilizing Calgon "TG" will be run (see discussion under "A" and "B" Loops).

7. Probolog Operations. In addition to the tests made on the test loop and steam-heated test condensers already described, a total of eleven process freon condensers were examined with the Probolog. Eight of these were K-31 condensers removed during the ALC program. All eight were found to be pitted. Acid cleaning and leak testing of one of these detected 33 leaking tubes. All eight were sent to Goslin-Birmingham for retubing.

   Two K-33 condensers were examined, and, although they were found to be pitted, it was recommended that they be retained as spares.

   One K-29 condenser was examined and found to be pitted. This condenser contained 21 leaking tubes after acid cleaning and leak testing.

Tests and operating results of the individual loops are as follows:

A Loop (K-25 East) and B Loop (K-25 West)

The combined "A" and "B" loop pumpage was constant at 40 million gallons per day. There were slight indications of loss of heat transfer characteristics; however, as the "A" loop return temperature dropped 0.5° to 118.5° F, and the

"B" loop return temperature dropped 1.0° to 111° F. The "A" loop average water control valve position, as indicated in K-309-2, opened from 44 to 48 per cent open; and the "B" loop average water control valve position, as indicated in K-304-4, opened from 38 to 40 per cent open.

The conditions of the recent Calgon "TG" test run in the K-892 test loop have been extended to a plant-scale trial for about three months in the "A" and "B" recirculating water systems. The Calgon "TG" material was already on hand and would have been declared surplus if not soon used. As compared with the present "A" and "B" loop treatment, it is believed that the treatment on trial will be more economical due to the small phosphate feed rate required to maintain 1 to 2 ppm metaphosphate and the almost complete elimination of acid requirements at an operating pH of 7.7 to 7.8. It also appears that the heat transfer rates and the copper corrosion rates will be better than now being experienced. On the negative side, it seems certain that the steel corrosion rate will not be as good as that now being obtained.

C Loop (K-27/K-29)

With a small increase in power load, the "C" loop pumpage increased 0.5 million gallons per day to 40, and the return temperature increased 2° to 135° F.

The K-27 water control valves, as indicated in K-402-3, averaged closing from 47 to 40% open. Reversing the improvement shown in the last report period, the K-29 water control valves, as indicated in K-502-1, opened from 40 to 50% open.

The improvement noted in K-402-3 is undoubtedly due to raising the stage temperature approximately 30° F for all ten cells and converting the final three cells of this section to the badger cluster arrangement.

E Loop (K-31)

There were no indications of any appreciable change in heat transfer characteristics during this report period.

G Loop (K-33)

There were evidences of definite improvement in heat transfer characteristics by February 14 of this report period. By that date the pumpage requirements had decreased from 225 to 217 million gallons per day and the water control valves, as indicated in K-902-4, had closed from 61 to 55% open.

On February 15, the "G" loop supply temperature was dropped to 95° F for a special cascade test and this apparently adversely affected heat transfer. By the end of February, with normal operating conditions, the pumpage had increased to 220 million gallons per day and the K-902-4 water control valves opened from 55 to 67% open.

Monthly Average Water Analyses

Attached are separate water analyses sheets for January and February, 1958.

C. C. Fowlkes
C. C. Fowlkes

J. L. Gamble
J. L. Gamble

Approved: W. C. Hartman
W. C. Hartman
Process Utilities Department

MONTHLY AVERAGE WATER ANALYSES - JANUARY, 1958

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATION WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	158	140	86	236	235	350	430	412
Metaphosphate as $NaPO_3$	0.52	0.02	0.02	9.08	8.07	8.06	7.01	6.00
Orthophosphate as $NaPO_3$	0.37	0.05-	0.05-	9.41	9.87	9.73	11.72	11.74
Total Hardness as $CaCO_3$	101	116	75	142	141	200	260	254
Calcium as $CaCO_3$	68	77	37	84	78	107	128	134
M-Alkalinity as $CaCO_3$	64	88	42	15	14	9	9	8
Turbidity as SiO_2	15.9	12.3	3.5	6	6	6	6	7
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.06	0.06	0.06	0.06	0.09
Copper as Cu - Total	0.05-	0.05-	0.05-	0.07	0.07	0.06	0.09	0.13
Total Iron as Fe	0.40	0.46	0.33	0.44	0.46	0.51	0.57	0.54
Sulphate as (SO_4)	8	5	6	76	77	158	237	212
Suspended Solids	2	10	1	2	2	2	2	3
Manganese as Mn	-	0.05-	0.05-	0.05	0.06	0.05	0.05	0.05-
Chromates as CrO_4	-	-	-	-	-	18.8	19.4	11.6
pH	7.16	7.88	9.68	6.70	6.70	5.99	6.00	6.04
Recirculating Water Treatment Used	-	-	-	Calgon		Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$1.103		$1.969	$1.376	$1.233
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	-	5.25	3.72	3.45

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - FEBRUARY, 1958

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A"	"B"	"C"	"E"	"G"
Total Dissolved Solids	151	133	84	285	286	374	373	407
Metaphosphate as $NaPO_3$	0.08	0.00	0.00	10.08	10.51	8.52	6.89	5.98
Orthophosphate as $NaPO_3$	0.42	0.03	0.03	12.96	13.13	10.80	9.09	11.36
Total Hardness as $CaCO_3$	112	118	76	166	142	211	245	245
Calcium as $CaCO_3$	76	78	42	92	89	110	118	124
M-Alkalinity as $CaCO_3$	65	80	46	14	14	8	9	8
Turbidity as SiO_2	16.7	13.5	2.9	6	5	4	5	5
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.06	0.06	0.05	0.06	0.07
Copper as Cu - Total	0.05-	0.05-	0.05-	0.06	0.06	0.05	0.06	0.07
Total Iron as Fe	0.33	0.32	0.20	0.32	0.30	0.33	0.27	0.30
Sulphate as (SO_4)	15	10	10	147	152	197	220	227
Suspended Solids	1.5	4.2	0.5-	2.5	2.2	1.9	2.2	2.3
Manganese as Mn	0.06	0.05-	0.05-	0.06	0.06	0.05	0.07	0.05
Chromates as CrO_4	-	-	-	-	-	20.0	18.5	11.6
pH	7.18	8.20	10.10	6.71	6.71	6.00	6.00	6.07
Recirculating Water Treatment Used	-	-	-	Calgon		Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.987		$1.686	$1.388	$1.257
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-		4.53	3.59	3.42

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

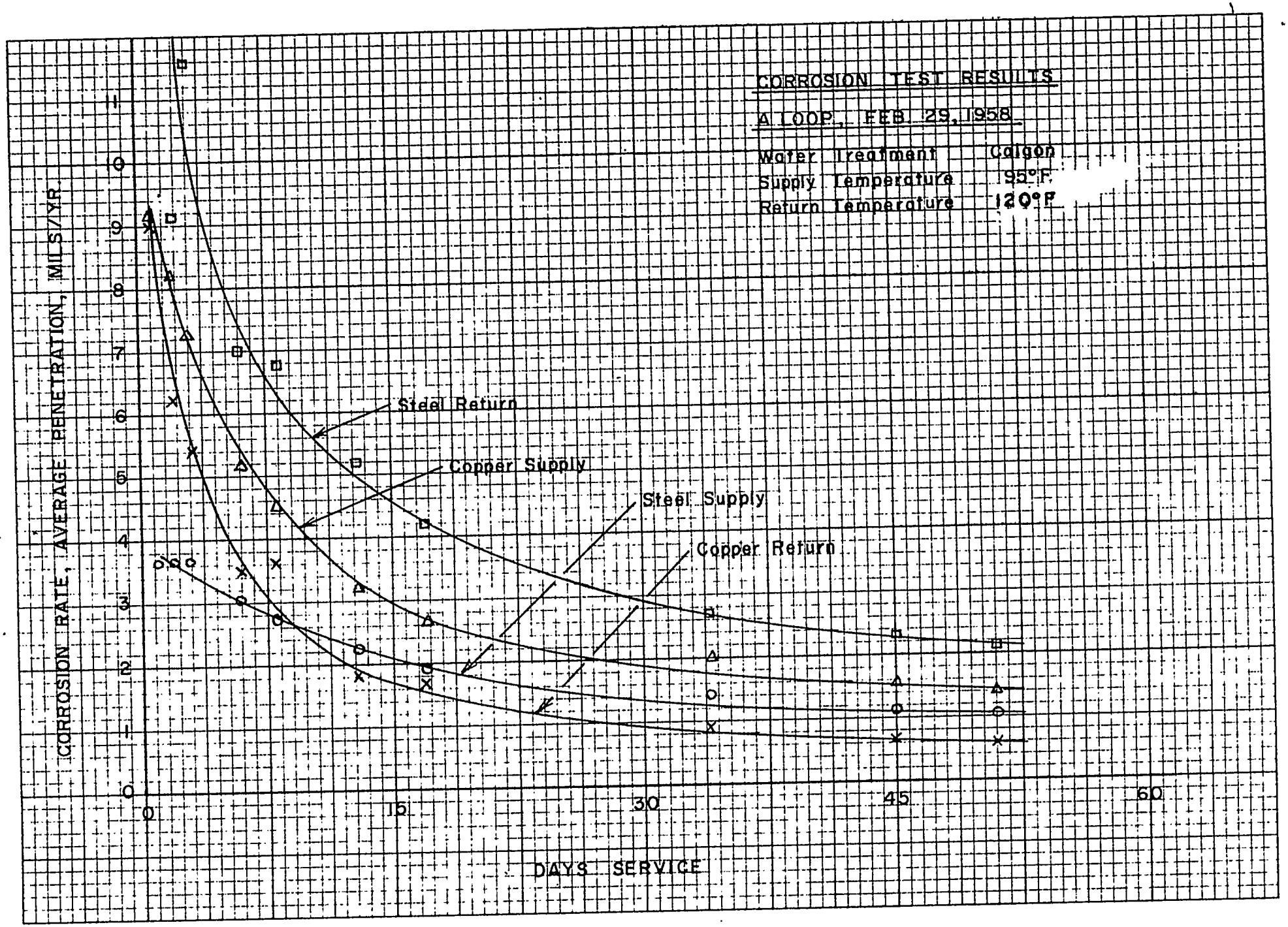

FIG. 1

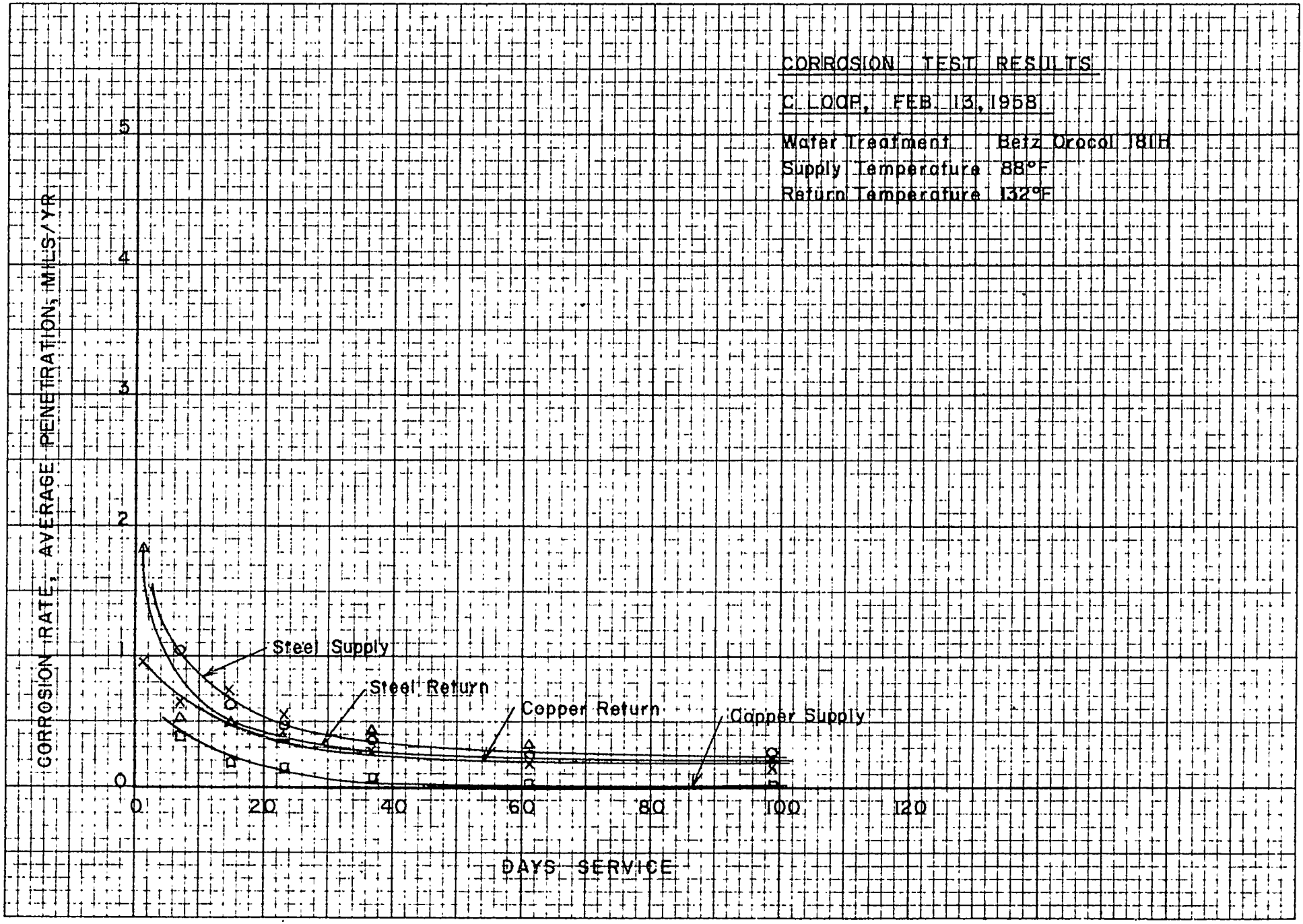

FIG 2

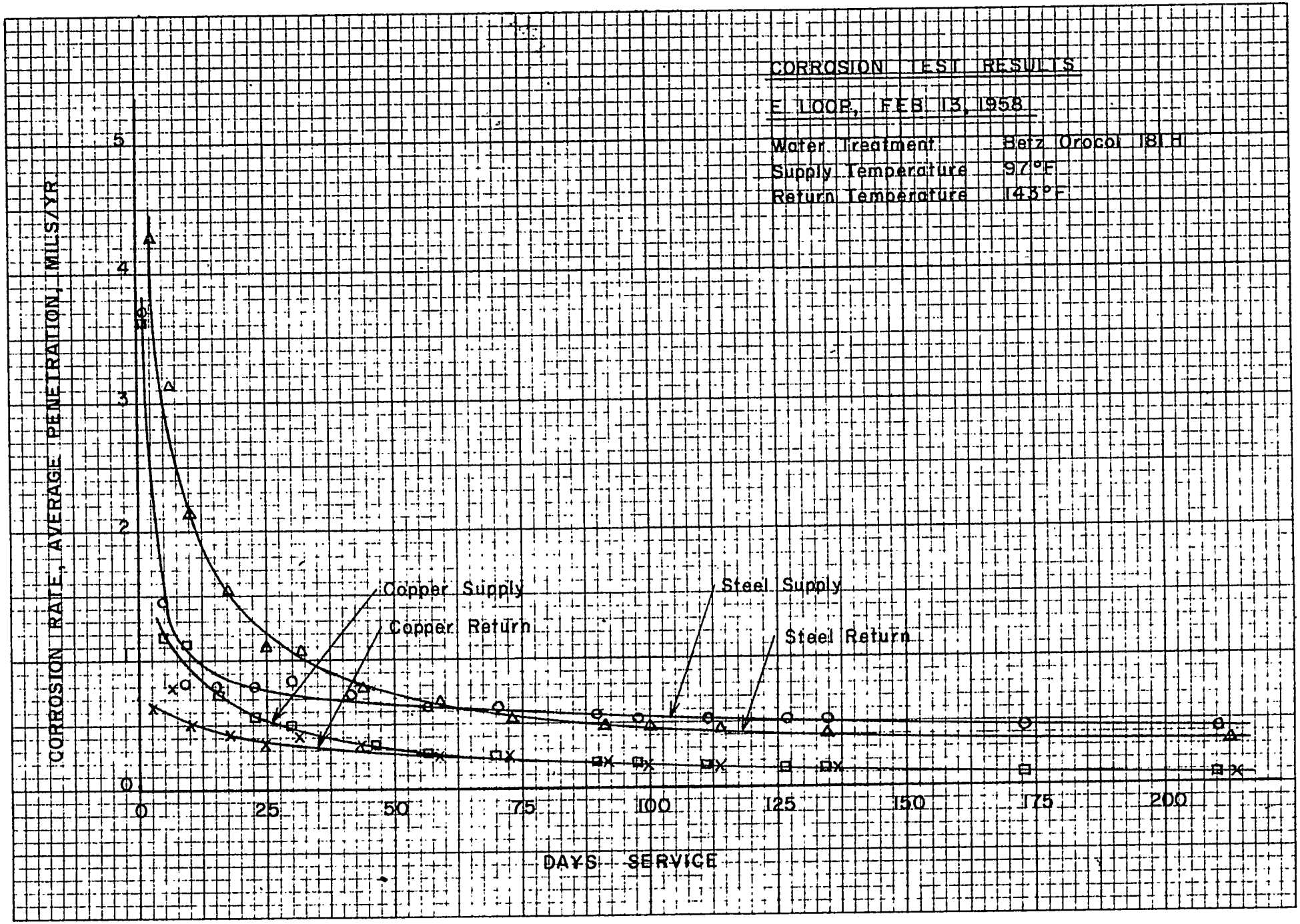

FIG 3

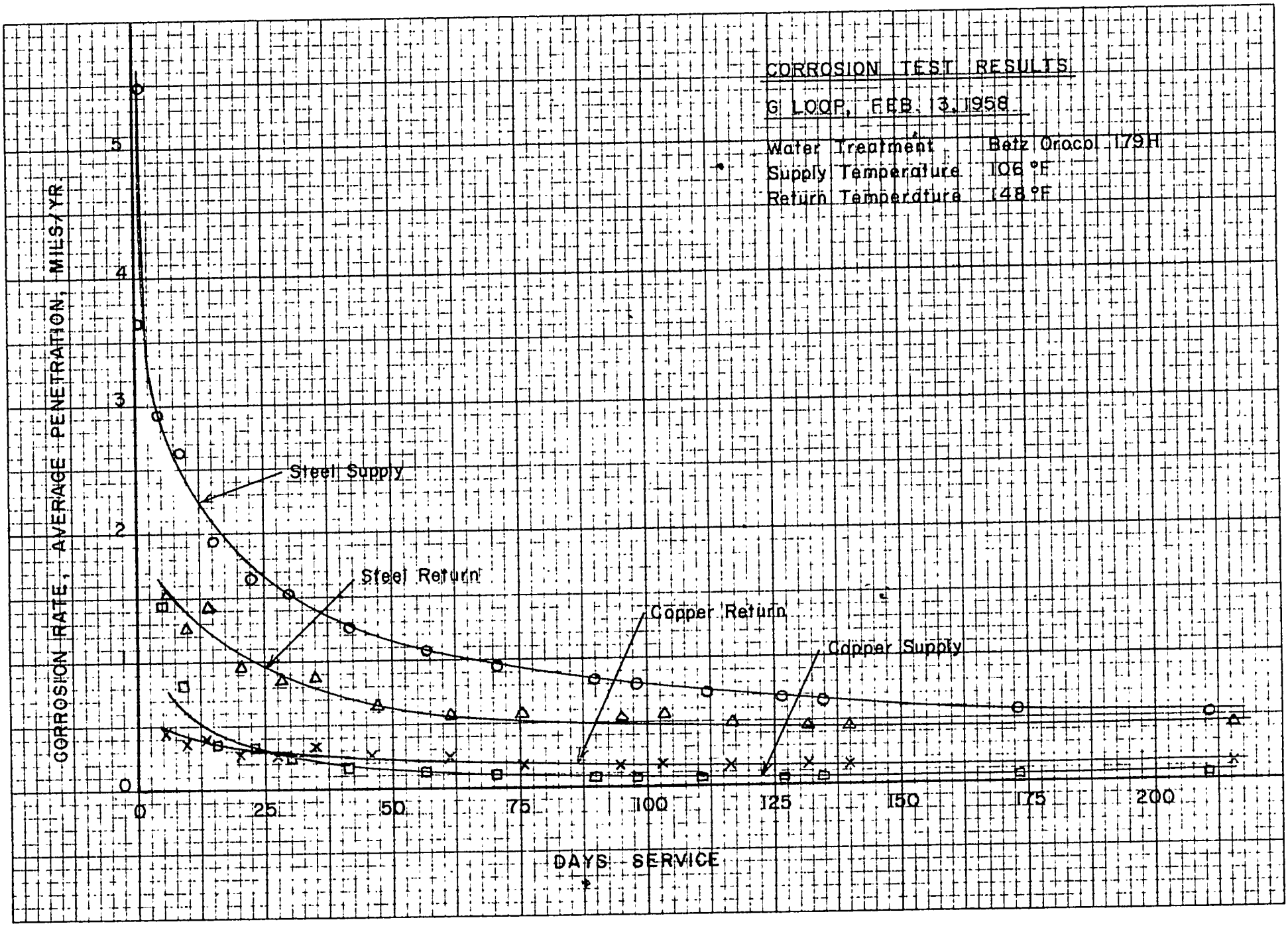

FIG. 4

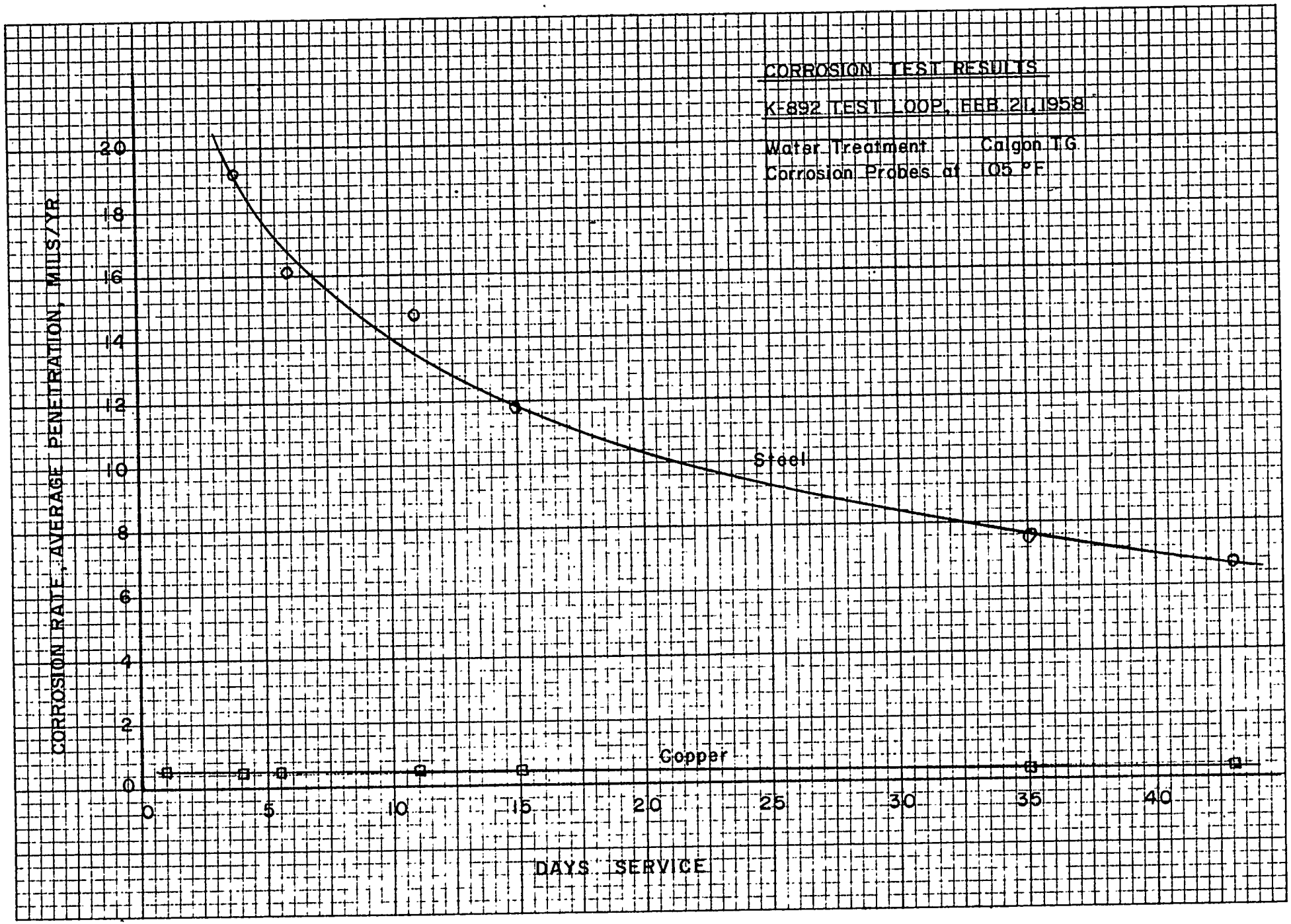

FIG. 5

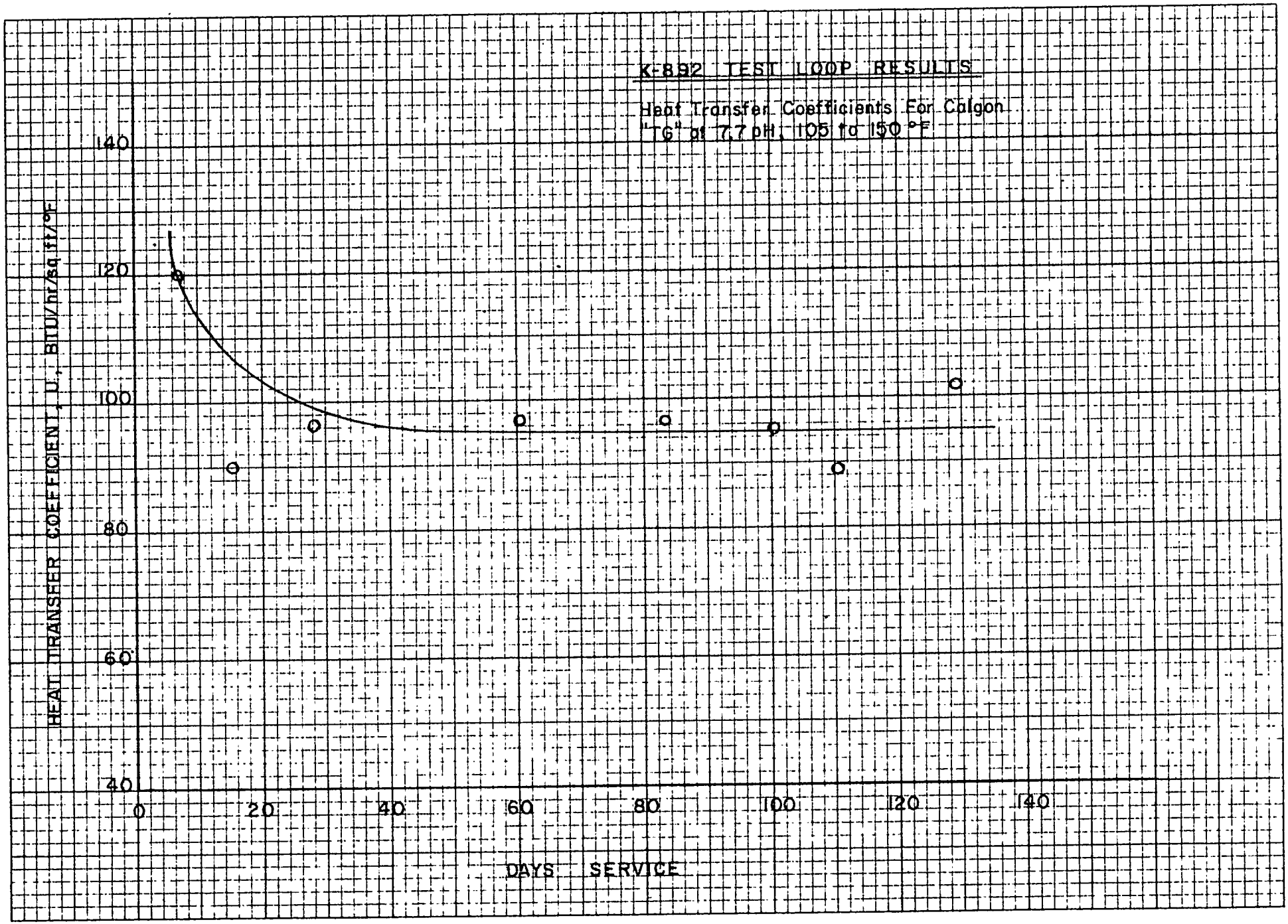

FIG. 6

Date of Issue: May 29, 1958

Report Number: KP-570
Part No. 28
METALLURGY

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SUMMARY OF RECIRCULATING WATER TREATMENT AND TESTS FOR MARCH AND APRIL, 1958

M. A. Fletcher and J. L. Gamble

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UNION CARBIDE NUCLEAR COMPANY
OAK RIDGE GASEOUS DIFFUSION PLANT
Production Division
Process Utilities Department

INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

A Division of Union Carbide and Carbon Corporation

To: Mr. H. G. P. Snyder
K-303-7

Plant: ORGDP

Date: May 29, 1958

Copies To: Attached Distribution

Subject: Summary of Recirculating Water Treatment and Tests for March and April, 1958

KP-570, Part No. 28

Summary

This report describes the results of all recirculating water treatment tests and outlines the operating results of all recirculating water systems for March and April, 1958.

Corrosion Investigations

1. Corrosion Rates. Corrosion rates were determined for "A" and "B" recirculating water loops as shown on Figure 1. Probes were installed at the beginning of the use of Calgon TG in "A" and "B" loops. Very little change was noted in the steel corrosion rates when the treatment was changed from plain Calgon, but a noticeable drop was apparent in copper corrosion rates, especially the copper return. Copper rates are about the same as obtained with Calgon TG in the K-892 test loop, but the steel rates are considerably lower --the steel rate in the test loop being about three times as high as actually obtained in "A" and "B" loops. Good correlation had been previously obtained between test loop results and actual loop experience. It has been concluded that velocity effects are more important in some types of treatment than in others, being a primary concern in the straight polyphosphate treatments. Field-type probes in which the velocity is controlled are being obtained for use in the test loop rather than the presently used immersion type probes.

2. K-892 Test Loop. Due to the possibility of higher water temperatures in the recirculating water systems, it was decided that data should be obtained in the K-892 test loop of proposed water treatments for high-temperature operation. The first test selected was the Betz-proposed Zinc Dianodic treatment. Conditions for this test were:

Make-up	- Clinch River, partially softened
Supply Temperature	- 100° F
Return Temperature	- 180° F
Tube Velocity	- 4 feet/second
pH	- 6.0
Metaphosphate	- 1 to 2 ppm

Total Phosphate	- 12 ppm
Chromate	- 24 ppm
Zinc	- 1 ppm
Calcium	- 120 ppm maximum

The test was started with Betz Orocol 155Z, supplied by Betz Laboratories. However, due to the low retention time in the test loop, it became apparent that to maintain the chromate level recommended with the Betz formulation it would be necessary to carry metaphosphate concentrations above 5 ppm. Since it was desired to obtain data at low metaphosphate levels, a simulated Orocol was prepared, using disodium phosphate to bring the total phosphate within the recommended limits.

Corrosion rates for this test are shown on Figure 2; and, while they are somewhat higher than we had hoped for, they are considered satisfactory. Heat transfer, however, gradually deteriorated, with about 50 per cent loss after 25 days' operation (see Figure 3).

Consultation with Betz representatives resulted in a decision to rerun the test at somewhat higher metaphosphate levels, their reasoning being that the metaphosphate will act as a dispersing agent and result in better heat transfer.

Probolog results on the test condenser and examination of copper and steel specimens indicated no signs of pitting attack.

3. Probolog Results. In addition to the Probolog results on the test condenser, a total of seven process freon condensers were inspected.

Five of these were K-31 condensers removed during the ALC program; four were retubed on the basis of the Probolog results. One was found to be in somewhat better condition than those previously checked; this one was acid cleaned and leak tested, and only five leaking tubes were found.

One K-31 condenser was probed in place. This unit was a Ross rebuilt condenser, first installed on October 15, 1956. It was first probed on April 30, 1957, and found to be pitted. This inspection, eleven months later, revealed no additional pitting.

One K-29 condenser was inspected. This was a spare condenser which was badly pitted. Several tubes were removed and split to correlate the Probolog charts with actual pits.

4. Underground Corrosion, "C" Loop Recirculating Water Lines. A pipe-to-soil potential test was completed on the "C" loop recirculating water distribution system to determine possible locations of underground corrosion. Three locations of high corrosion potential were selected, and the lines were excavated for visual inspection. This

inspection revealed only widely scattered areas of minor corrosion attack, and it was concluded that at this time no necessity exists for a cathodic protection system for these lines.

Make-up Water (K-892 A and B)

The cold softening of Clinch River make-up water to reduce the amount of scale-forming compounds added to the recirculating water systems has been satisfactory. Operation of the recirculating water systems at higher concentrations has reduced blowdown and the amount of treatment chemicals necessary for corrosion inhibition. Softening was begun July 2, 1957, and though operation has not been perfect, it has steadily improved.

Noted in the following table are typical results of softening:

Characteristics	Clinch River	Make-up
Turbidity, ppm	26.3	2.3
Alkalinity, ppm	92.9	40.6
Total Hardness, ppm	115.1	61.7
Calcium, ppm	77.6	30.8

Softening has been effective in reducing chemical usage for recirculating water treatment as follows:

Sulfuric Acid	- 55%
Chlorine	- 60%
Orocol	- 40%

Tests and operating results of the individual loops are as follows:

A Loop (K-25 East) and B Loop (K-25 West)

The combined "A" and "B" loop pumpage decreased from 40 to 35 million gallons per day. This decrease is attributed mainly to a power reduction of about eleven megawatts in March and also to a stage temperature increase for four cells in K-302-1.

With process operational variations, the heat transfer changes are difficult to evaluate. However, there may have been some improvements, as the "A" loop return water temperature increased 1° to 119.5° F, and the "B" loop return water temperature increased 0.5° to 111.5° F. The "A" loop average water control valve position, as indicated in K-309-2, closed from 48 to 47 per cent open; and the "B" loop water control valves, as indicated in K-304-4, closed from 40 to 29 per cent open.

On April 15, plain Calgon was substituted for Calgon TG due to the chemical treatment of "A" cooling tower for fungi control. As this treatment

(MarTreat) involves the use of zinc sulphate, the pH of "A" and "B" loops was dropped to 6.7 for this period to prevent excessive deposition, and the presence of soluble zinc in the cooling water obviated the use of Calgon TG, which is plain Calgon with added zinc.

C Loop (K-27/K-29)

Despite a power increase of 5 megawatts in K-29 during this report period, there was no appreciable change in either total pumpage requirements or the return water temperature.

The K-27 water control valves, as indicated in K-402-3, averaged closing from 40 to 37.5 per cent open. The K-29 water control valves, as indicated in K-502-1, closed from 50 to 40 per cent open.

Corrosometer readings taken during the first of this period indicate no appreciable changes in the corrosion rates for either steel or copper.

E Loop (K-31)

There were no significant changes in heat transfer characteristics during this report period. The return water temperature was constant at about 141° F, and the water control valves, as indicated in K-602-3, remained 40 to 42 per cent open. As a result of a 10- to 15-megawatt power increase on April 10, pumpage requirements increased about five million gallons per day.

A set of Corrosometer readings which were taken during the first of this report period showed no significant change from the last reported corrosion rates for "E" loop.

G Loop (K-33)

There are evidences of definite loss of heat transfer characteristics during this report period. Despite a power reduction of 10 to 20 megawatts, the pumpage requirements increased about five million gallons per day, and the return water temperature dropped 1.5° F.

The only set of corrosion readings taken early in this report period indicates no appreciable change from the last results reported.

M. A. Fletcher
M. A. Fletcher

Approved: C. C. Fowlkes
C. C. Fowlkes
Process Utilities Department

J. L. Gamble
J. L. Gamble

MONTHLY AVERAGE WATER ANALYSES - MARCH, 1958

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	120	120	84	228	362	446	412
Metaphosphate as $NaPO_3$	0.04	0	0	3.0	7.6	7.1	5.9
Orthophosphate as $NaPO_3$	0.15	0.05-	0.05-	6.4	9.6	10.4	10.8
Total Hardness as $CaCO_3$	86	114	77	150	217	273	261
Calcium as $CaCO_3$	60	76	43	93	114	143	134
M-Alkalinity as $CaCO_3$	55	83	44	38	8	10	7
Turbidity as SiO_2	19.1	20.8	2.4	12	8	8	9
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Total Iron as Fe	1.11	1.06	0.30	0.43	0.38	0.36	0.37
Sulphate as (SO_4)	23	15	18	63	190	212	203
Suspended Solids	11.2	14.3	0.5	8.8	2.9	3.0	3.7
Manganese as Mn	0.05-	0.05-	0.05-	0.05	0.06	0.05	0.05
Chromates as CrO_4	-	-	-	-	22.0	22.7	12.5
pH	7.25	8.30	10.02	7.71	6.00	6.00	6.02
Recirculating Water Treatment Used	-	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.898	$1.709	$1.357	$1.233
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	4.61	3.06	3.55

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - APRIL, 1958

P. P. M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	127	137	84	279	345	485	408
Metaphosphate as $NaPO_3$	0.01	0	0	5.8	7.1	7.6	6.8
Orthophosphate as $NaPO_3$	0.26	0.04	0.04	8.3	8.4	11.1	10.7
Total Hardness as $CaCO_3$	103	112	73	176	194	270	244
Calcium as $CaCO_3$	68	80	40	98	96	131	115
M-Alkalinity as $CaCO_3$	64	80	40	24	8	9	6
Turbidity as SiO_2	22.6	24.0	2.5	13.8	5.0	6.6	5.3
Copper as Cu -Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu -Total	0.05-	0.05-	0.05-	0.06	0.05	0.05	0.05
Total Iron as Fe	1.09	1.66	0.27	0.42	0.38	0.35	0.40
Sulphate as (SO_4)	23	13	17	96	161	207	200
Suspended Solids	10.2	29.5	0.4	5.5	2.0	2.7	2.3
Chromates as CrO_4	-	-	-	-	18.1	20.3	11.5
pH	7.53	8.32	10.00	7.21	6.00	6.00	6.02
Recirculating Water Treatment Used	-	-	-	Calgon TG, Calgon (15 days each)	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.723	$1.607	$1.261	$1.105
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	4.34	3.44	3.22

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

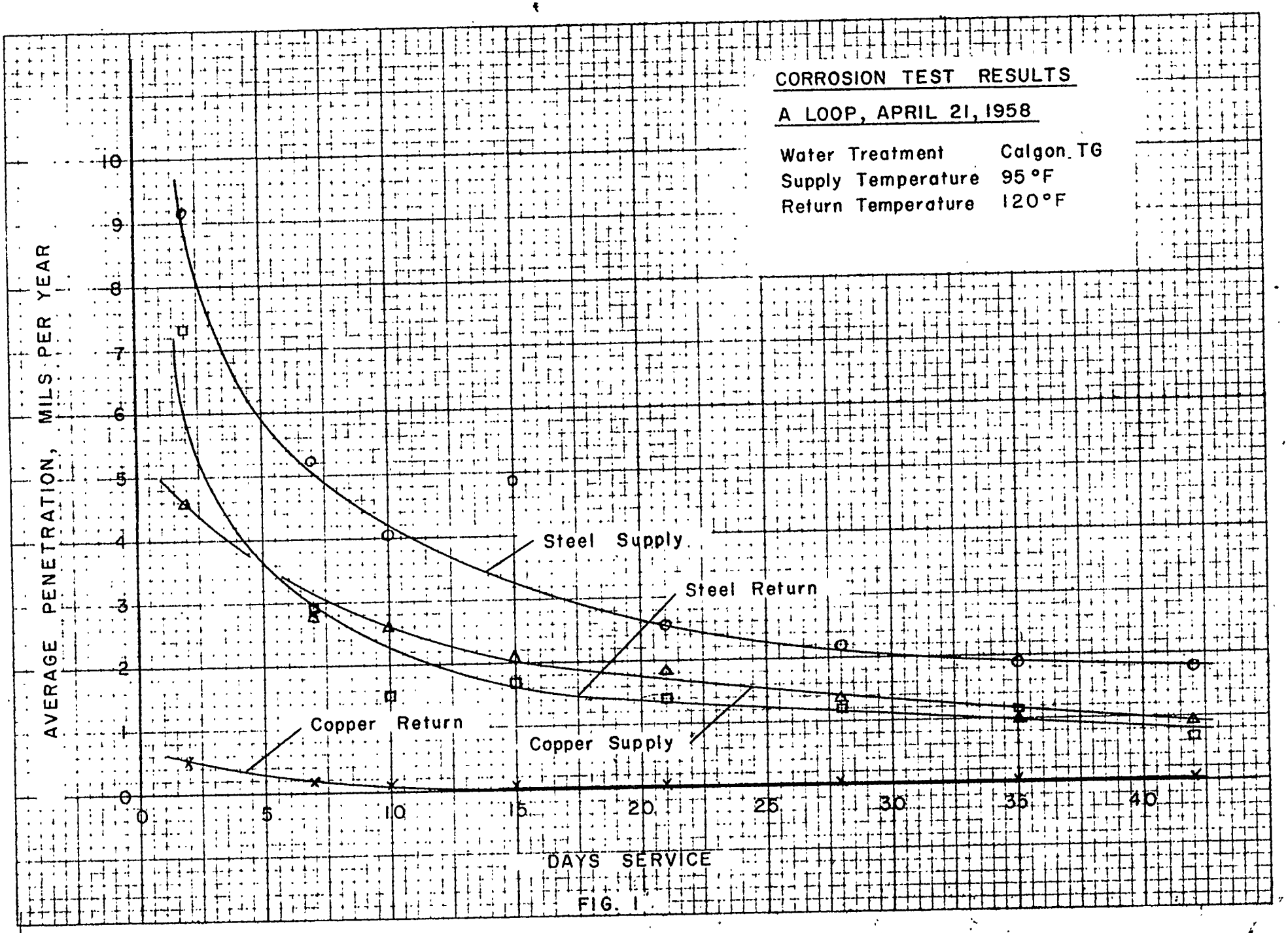

FIG. 1

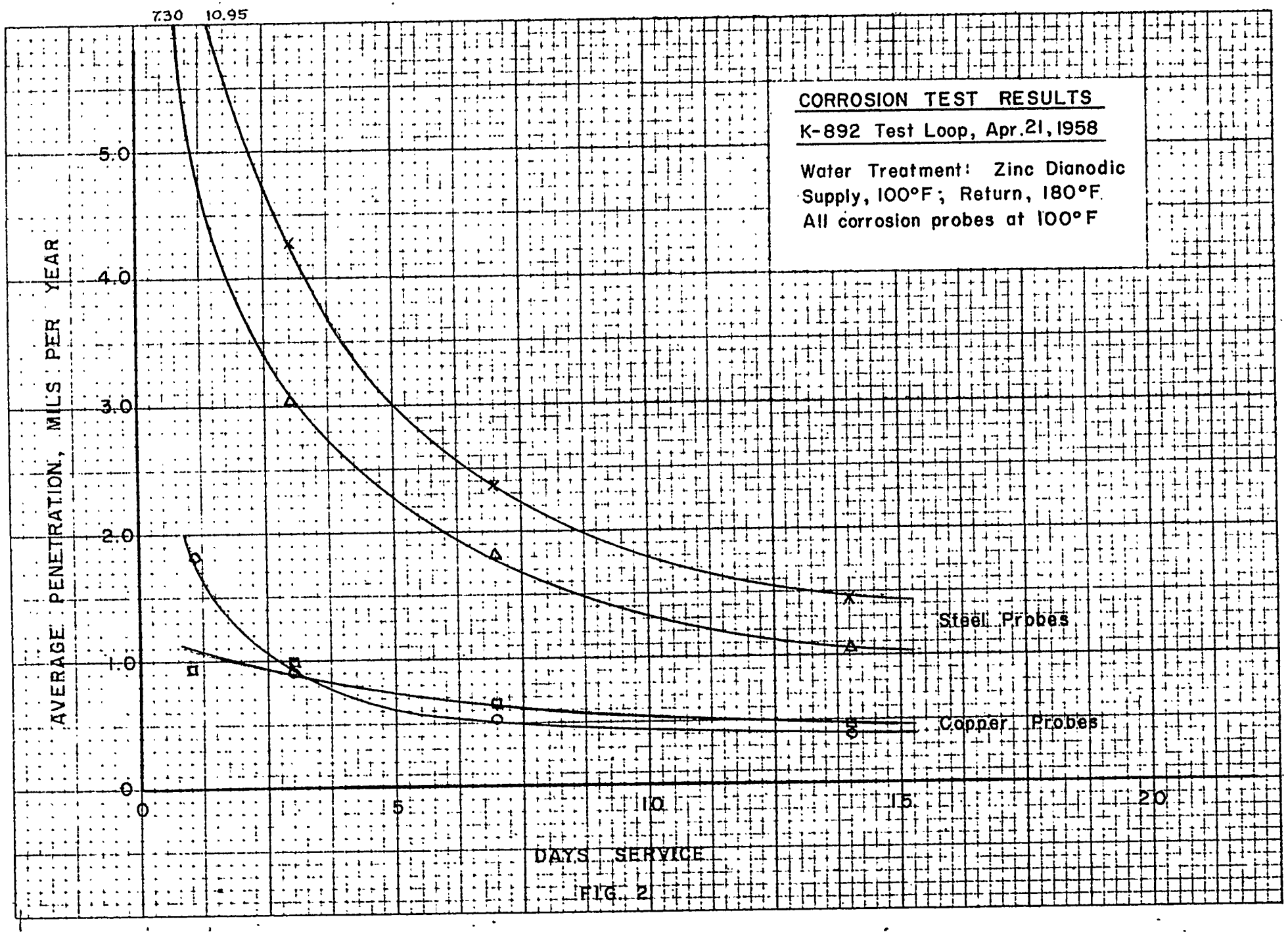

FIG. 2

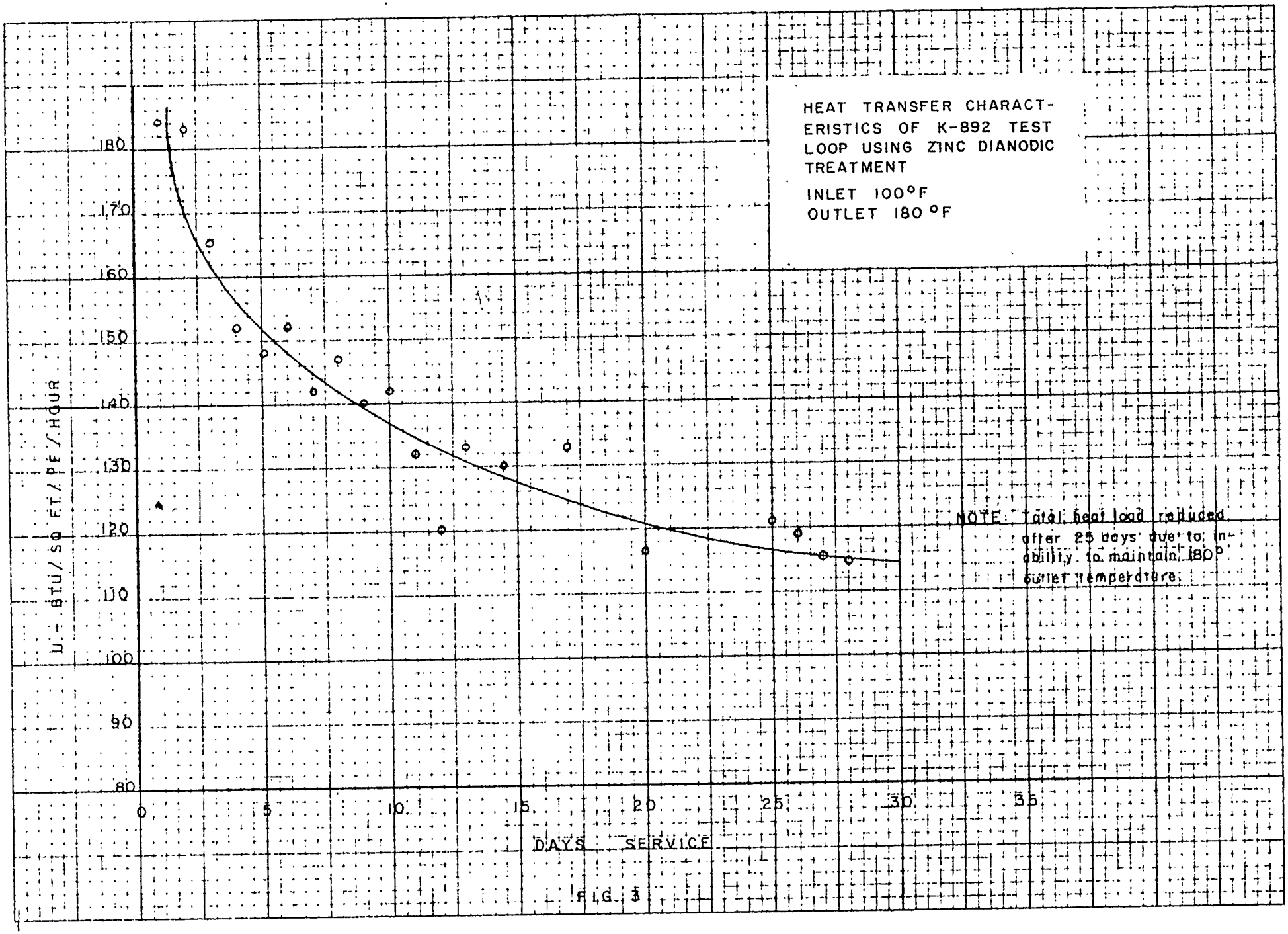

FIG. 3

Date of Issue: August 6, 1958

Report Number: KP-570
Part No. 29

SUMMARY OF RECIRCULATING WATER TREATMENT AND TESTS FOR MAY AND JUNE, 1958

M. A. Fletcher and J. L. Gamble

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UNION CARBIDE NUCLEAR COMPANY
OAK RIDGE GASEOUS DIFFUSION PLANT
Production Division
Process Utilities Department

INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

A Division of Union Carbide and Carbon Corporation

To: Mr. H. G. P. Snyder
K-303-7

Plant: ORGDP

Date: August 6, 1958

Copies To: Attached Distribution

Subject: Summary of Recirculating Water Treatment and Tests for May and June, 1958

KP-570, Part No. 29

Summary

This report describes the results of all recirculating water treatment tests and outlines the operating results of all recirculating water systems for May and June, 1958.

Corrosion Investigations

1. Corrosion Rates. New probes were installed in all loops except "A" and "B," which had been replaced previously. Corrosion data were collected with the Corrosometer and are illustrated in the attached curves, Figures 1 through 4. No significant change was noted in corrosion rates for "A" loop, although the water treatment was not consistent as described later in this report. Corrosion rates for "C" and "E" loops, both of which use Orocol 181-H, are quite similar. In comparing these rates with the rates determined previously,[1] it is noted that the steel rates are now somewhat higher, although still considered to be satisfactory. The steel rates on these loops will be watched closely. Corrosion rates for "G" loop are almost identical to those determined previously.

2. K-892 Test Loop. The high-temperature simulated Zinc Dianodic test results reported previously[2] were verified by a partial rerun of the test at higher metaphosphate levels. Betz representatives had indicated that better heat transfer rates could be maintained at the higher metaphosphate level. That this did not occur is shown in Figure 5, which is a comparison of the heat transfer coefficients obtained by the two tests. The higher metaphosphate apparently had little effect on the loss of capacity. It should be noted that the 180° outlet water temperature condition is very severe and that little work has been done previously at these temperatures.

---

[1] C. C. Fowlkes and J. L. Gamble, Summary of Recirculating Water Treatment and Tests for January and February, 1958, March 25, 1958, (KP-570, Part No. 27).

[2] M. A. Fletcher and J. L. Gamble, Summary of Recirculating Water Treatment and Tests for March and April, 1958, May 29, 1958, (KP-570, Part No. 28).

No further tests are presently planned at temperatures above 160° F, since indications now are that higher temperatures will not exist in the recirculating water systems.

The test loop was shut down and is now in the process of being retubed and cleaned in preparation for a test run utilizing a Dearborn Chemical Company product, X-1295, which is an experimental blend of phosphates and chromates with an organic additive.

3. Probolog Results. Six freon condensers removed from K-31 during the A-line cooling program were inspected with the Probolog. It was recommended that all six of the condensers be retubed. One of the condensers, predicted on the basis of Probolog results to be in worst condition, was acid cleaned in the K-1401 cleaning loop and 195 leaking tubes were found.

One condenser which had been retubed by Goslin-Birmingham was inspected prior to installation in K-602-5.8 for addition to the corrosion control program. There is now a total of seven K-31 condensers in this program, and all units except unit six are represented.

The K-892 test loop test condenser was probed in preparation for the Dearborn X-1295 test.

Make-up Water (K-892 A and B)

The make-up water demand for this period increased 712 thousand gallons per day. Treatment requirements of 53.0 ppm lime and 10.8 ppm ferric sulphate reduced the calcium content from 74.8 ppm to 34.9 ppm, or a 53.3 per cent reduction.

The new lime feed equipment did not accomplish any great improvement in operating efficiency but did permit chemical feed to be more consistent. Considerable maintenance has been necessary for making corrections and alterations to the conveying system, but this has not affected treatment operations.

A Loop (K-25 East) and B Loop (K-25 West)

There is some evidence of slightly improved heat transfer characteristics during this report period. The power for the K-25 Cascade increased about five megawatts, but the combined "A" and "B" loop pumpage remained unchanged at an average of 35 million gallons per day. The return water temperature from the "A" loop increased 0.5° to 120.0° F, and the "B" loop remained unchanged at 111.5° F. The "A" loop average water control valve position closed from 47 to 45 per cent open, and the "B" loop water control valves opened from 29 to 31 per cent open.

Untreated Poplar Creek water was used to supply 94 per cent of the make-up to these systems for this period.

C Loop (K-27/K-29)

The total pumpage requirements remained unchanged at 40 million gallons per day.

There were some indications of loss in heat transfer characteristics during this report period; however, a five-megawatt power increase was not reflected in an increase in recirculating water pumping requirements.

The return water temperature decreased 3° to 132° F. The K-27 water control valves, as indicated in K-402-3 increased from an average opening of 37.5 to 38.5 per cent, and the K-29 control valves, as indicated in K-502-1, opened from 40 to 52 per cent open. The power increase was in the K-29 Cascade.

One year of operation using Orocol 181-H to maintain chromate values between the range of 18 to 20 ppm as CrO_4 was completed June 10, 1958, as was recommended by the Betz Laboratories, Inc. Separate additions of dichromate were consistently added to the 181-H formulation to supplement for a chromate deficiency. Greater additions of Orocol 181-H would have increased the phosphate levels to exceed the limit of 20 ppm as PO_4 and resulted in deposition of calcium phosphate and, consequently, further loss of heat transfer throughout the entire system. Since there was only one new condenser installed during this period, we are considering lowering the chromate level to a range of 10 to 12 ppm as CrO_4 and reducing chemical treatment costs.

E Loop (K-31)

The "E" loop heat transfer characteristics appeared to vary directly with the total phosphate content of the system water; that is, the flow was increased and temperature of the return water decreased when the phosphate content was controlled close to the 20-ppm allowable limit. Heat transfer improved rapidly with the phosphate content lowered to 17 ppm. Over-all, the average heat transfer characteristics and operating conditions remained unchanged.

The Marley Company started on the chemical treatment of the cooling tower, but no adjustments in the feed of corrosion inhibitor chemicals were necessary during this report period.

G Loop (K-33)

"G" loop water was controlled at 4.2 concentration cycles instead of the allowable 4.6 in an attempt to improve heat transfer characteristics. However, the "G" loop recirculating water system continued to show evidence of loss of heat transfer in that pumpage requirements increased from 224 to 228 million gallons per day, and the water control valves opened an additional 19 per cent with no increase in power load.

Though the "G" loop system was consistently lower than "E" in dissolved solids, phosphates, hardness, and calcium, further reductions are necessary before an improvement in heat transfer can be realized.

Monthly Average Water Analyses

Attached are separate water analyses sheets for May and June, 1958.

Chromates and zinc in the "A" and "B" loop water are the result of MarTreating "A" cooling tower for fungi control. All other analyses show little variation from normal.

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Approved: C. C. Fowlkes
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Process Utilities Department

J. L. Gamble
J. L. Gamble

MONTHLY AVERAGE WATER ANALYSES - MAY, 1958

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	154	132	99	347	360	486	409
Metaphosphate as $NaPO_3$	0.03	0	0	7.27	6.32	6.52	5.64
Orthophosphate as $NaPO_3$	0.32	0.06	0.04	6.25	8.79	11.41	11.51
Total Hardness as $CaCO_3$	101	115	62	173	215	294	251
Calcium as $CaCO_3$	69	82	38	108	113	154	134
M-Alkalinity as $CaCO_3$	67	95	38	19	10	11	8
Turbidity as SiO_2	21.04	28.96	3.84	22	9	11	14
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.06	0.05	0.06	0.06
Copper as Cu - Total	0.05-	0.05-	0.05-	0.10	0.11	0.09	0.14
Total Iron as Fe	0.66	1.55	0.24	0.39	0.36	0.34	0.34
Sulphate as (SO_4)	20	10	11	138	150	200	190
Zinc as Zn	-	-	-	2.41	-	-	-
Suspended Solids	4.3	29.3	0.5	12.4	3.4	4.0	5.6
Chromates as CrO_4	-	-	-	11.6	2[illegible].2	19.4	10.1
pH	7.58	7.86	9.83	6.68	5.98	5.99	6.01
Recirculating Water Treatment Used	-	-	-	Calgon	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.980	$1.709	$1.296	$1.176
Total Chemical Treatment Costs In Mils per MM BTU Removed	-	-	-	-	4.63	3.43	3.41

All Water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - JUNE, 1958

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	162	157	98	451	356	488	361
Metaphosphate as $NaPO_3$	0.08	0.06	0.16	8.61	8.05	7.23	7.06
Orthophosphate as $NaPO_3$	0.20	0.09	0.12	5.39	8.90	11.48	11.14
Total Hardness as $CaCO_3$	98	114	62	223	201	263	218
Calcium as $CaCO_3$	62	74	35	141	100	134	107
M-Alkalinity as $CaCO_3$	64	92	35	21	9	10	8
Turbidity as SiO_2	23.0	9.9	2.9	38	5	7	5
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05	0.06	0.06	0.05
Copper as Cu - Total	0.05-	0.05-	0.05-	0.06	0.07	0.07	0.08
Total Iron as Fe	0.38	0.69	0.30	0.56	0.54	0.66	0.57
Sulphate as (SO_4)	16	9	13	213	172	222	201
Zinc as Zn	-	-	-	1.34	1.80	2.52	-
Suspended Solids	6.5	17.8	1.8	2.21	2.0	3.5	2.6
Chromates as CrO_4	-	-	-	9.4	21.5	20.0	10.1
pH	7.38	8.11	10.14	6.70	6.00	6.00	6.02
Recirculating Water Treatment Used	-	-	-	Calgon	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.996	$1.753	$1.275	$1.174
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	4.80	3.36	3.44

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

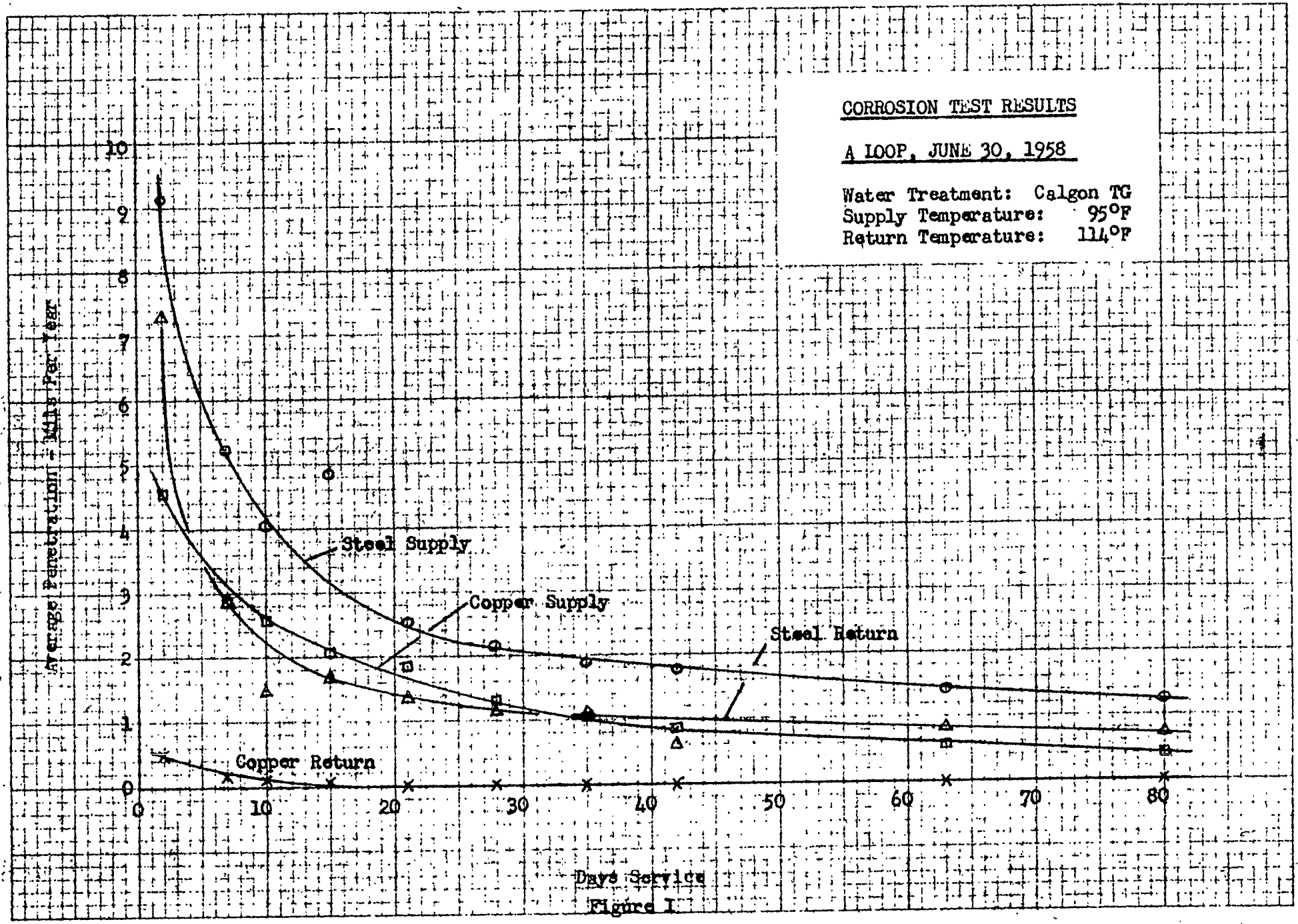

Figure I

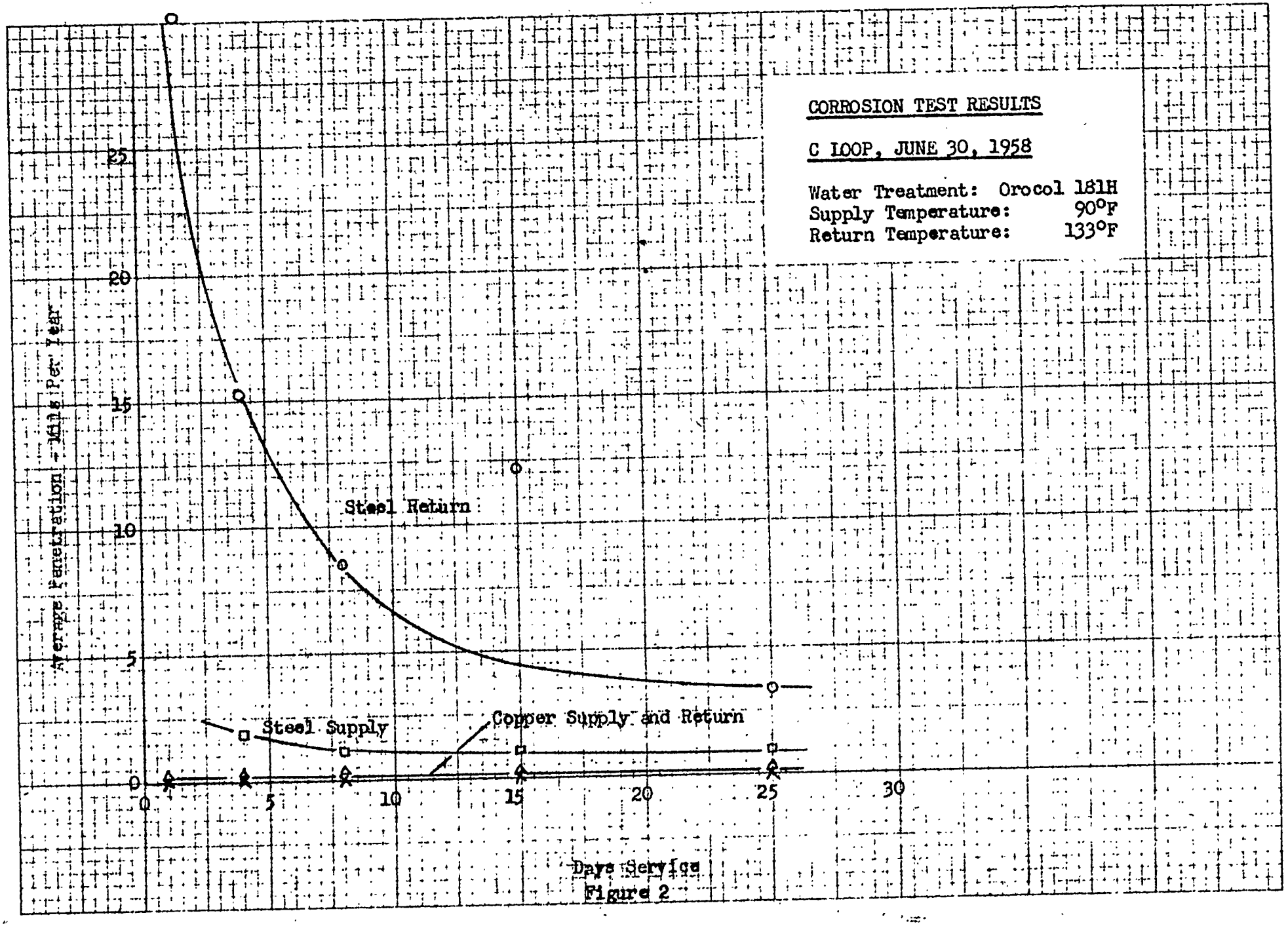

Figure 2

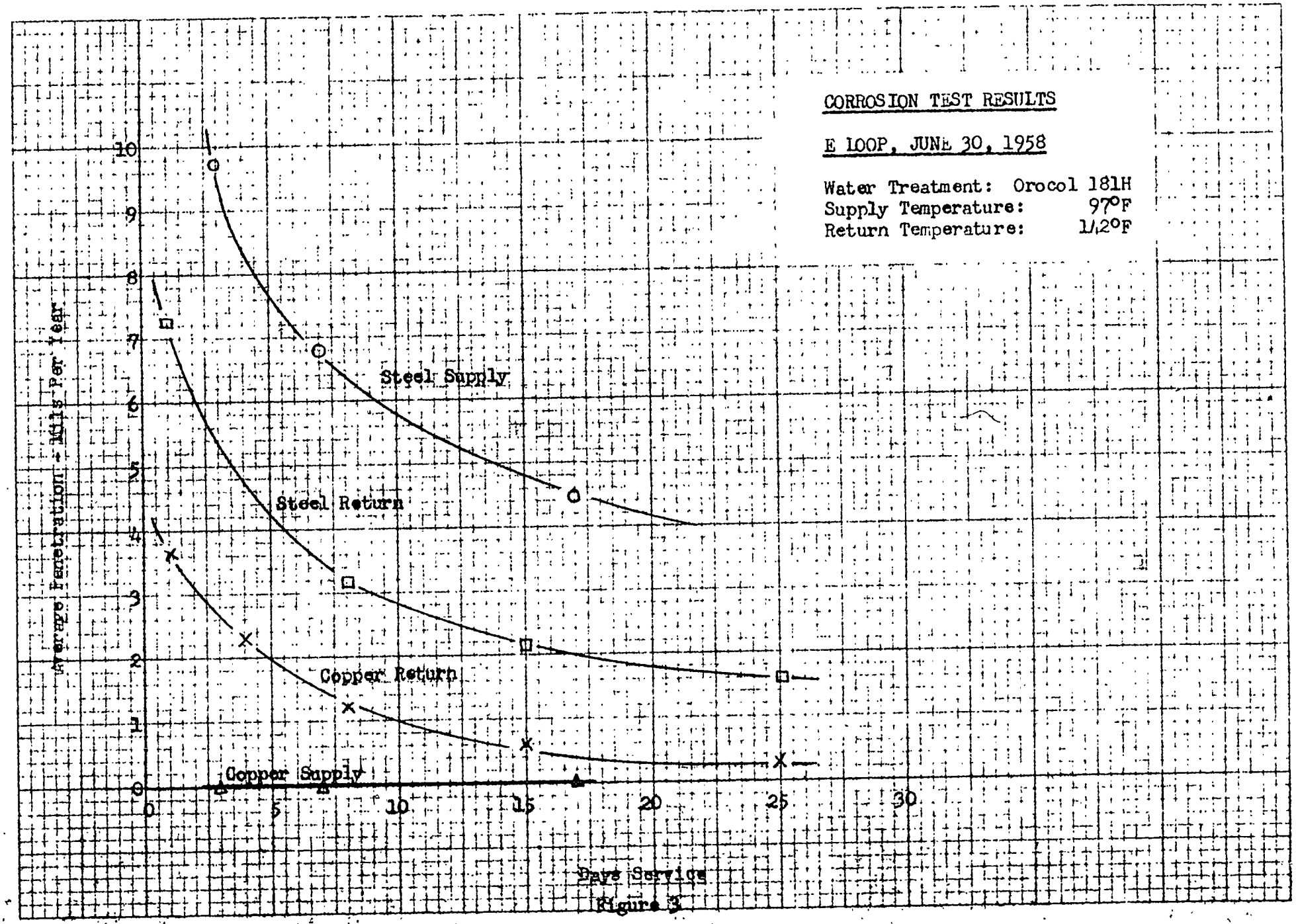

Figure 3

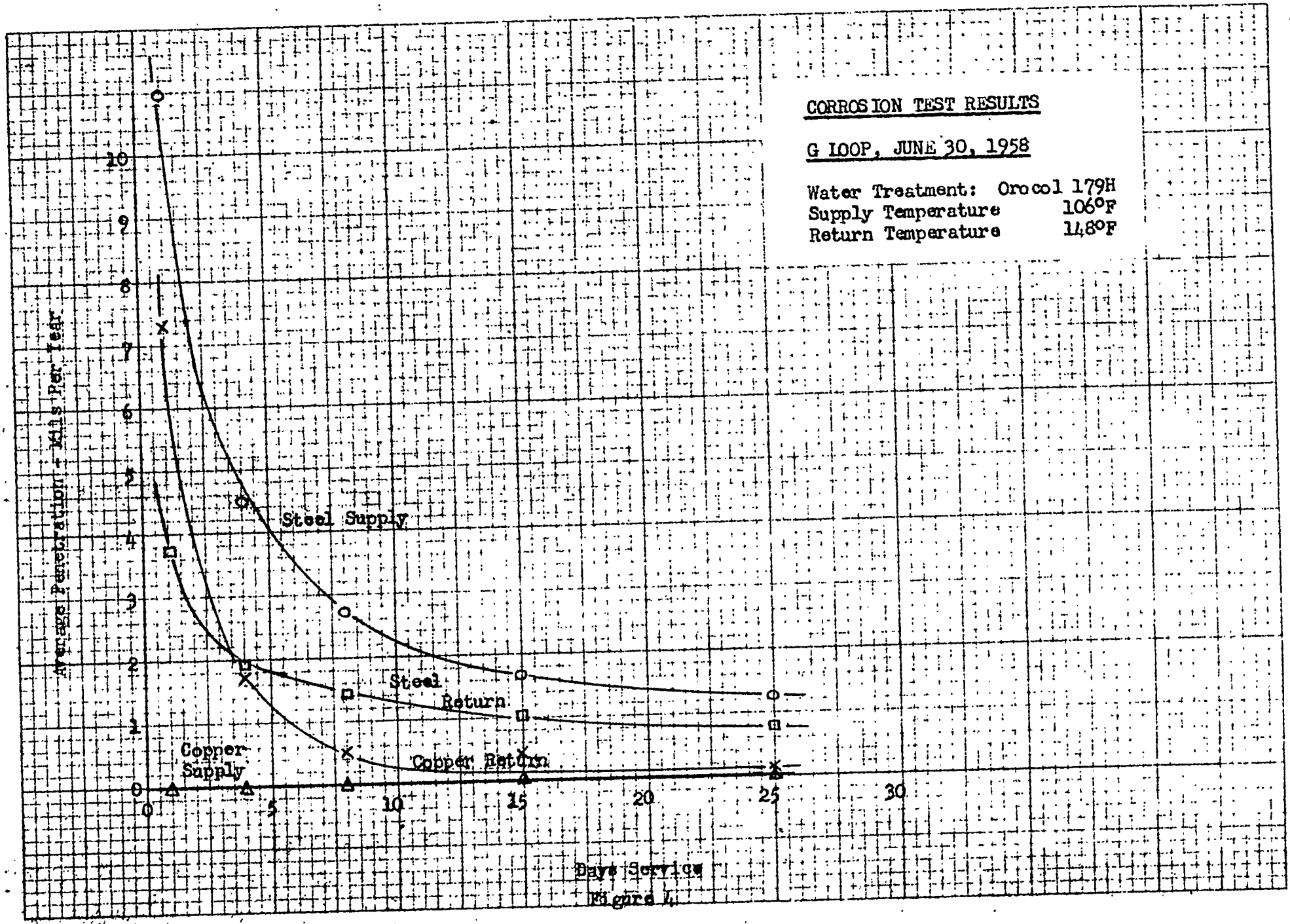

Figure 4

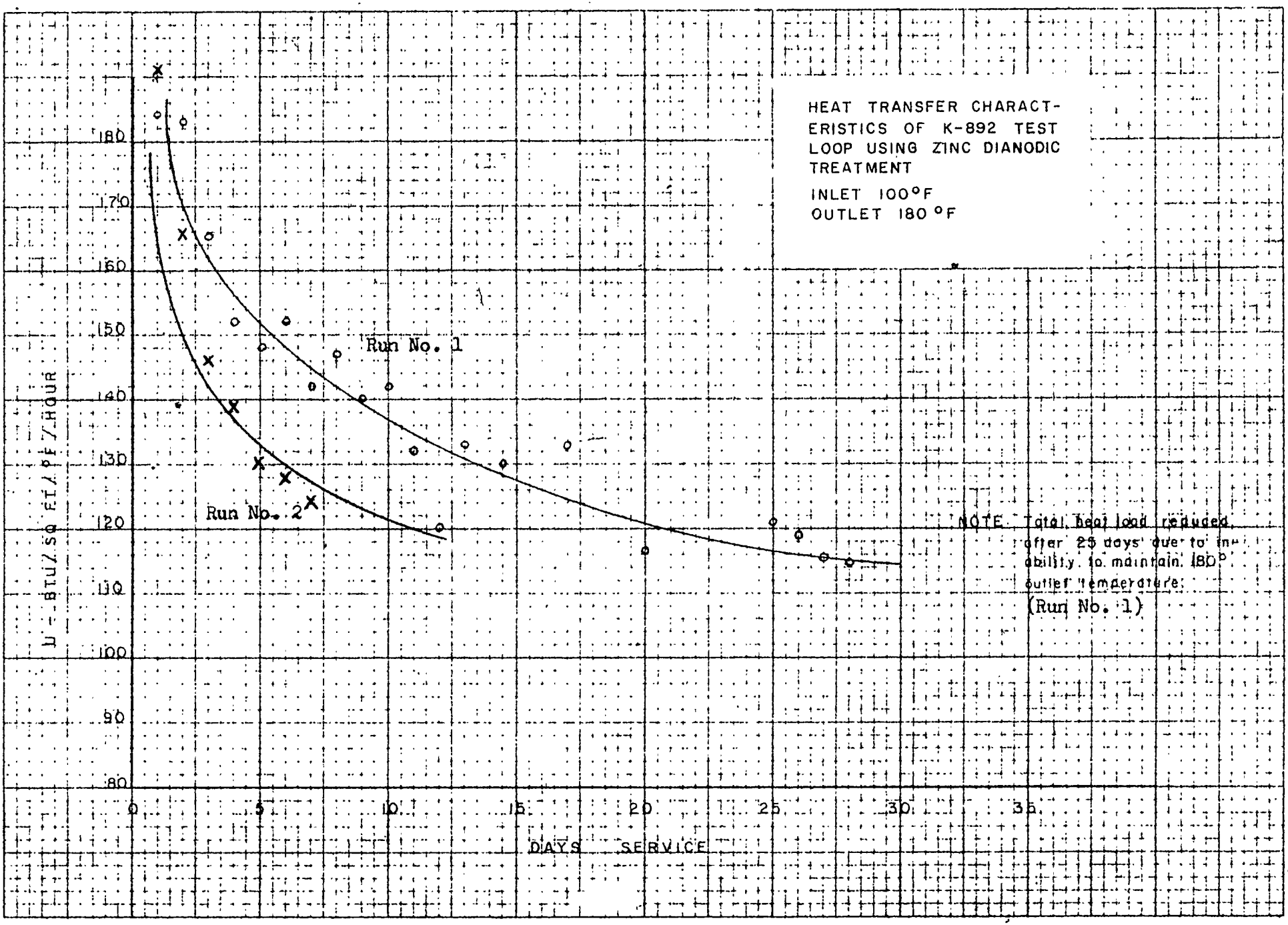

Figure 5

Date of Issue: December 5, 1958

Report Number: KP-570
Part No. 30

Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, Operating Contractor for the U.S. Atomic Energy Commission.

SUMMARY OF RECIRCULATING WATER TREATMENT AND TESTS FOR JULY, AUGUST, SEPTEMBER AND OCTOBER, 1958

M. A. Fletcher, C. C. Fowlkes,
and J. L. Gamble

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OAK RIDGE GASEOUS DIFFUSION PLANT
Production Division
Process Utilities Department

INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

A Division of Union Carbide and Carbon Corporation

To: Mr. H. G. P. Snyder
K-303-7

Plant: ORGDP

Date: December 5, 1958

Copies To: Attached Distribution

Subject: Summary of Recirculating Water Treatment and Tests for July, August, September and October, 1958

KP-570, Part No. 30

Summary

This report describes the results of all recirculating water treatment and tests and outlines the results of all recirculating water systems for the months of July, August, September, and October, 1958.

Corrosion Investigations

1. Corrosion Rates. Corrosion rates for all recirculating water loops were determined with the Corrosometer and are illustrated in the attached curves, Figures 1 through 4. All rates are considered to be satisfactory.

2. K-892 Test Loop. An eighty-day test of corrosion inhibitor chemicals supplied by Dearborn Chemical Company was completed. The inhibitor supplied was a blend of polyphosphate and chromate with an organic additive. Dearborn claimed that corrosion rates equal to or better than a straight phosphate-chromate treatment could be obtained, and that with the organic additive higher concentration ratios could be carried without loss of heat transfer capacity. Figure 5 shows graphically the results of the test.

   The heat transfer characteristics show that the Dearborn material was no better or no worse than any other inhibitor tested to date. Dearborn changed the formulation of the inhibitor during the test run in an attempt to improve the heat transfer, but no change was noted.

   The copper corrosion rates were satisfactory, as was expected at the relatively high (7.8) pH level carried. The steel corrosion rates, however, were not satisfactory. The sharp increase in the 105° steel corrosion rate is typical of a severe pitting type of attack, and visual examination of the steel probe confirmed the fact that severe pitting was occurring. The steel pitting has been attributed to the fact that with the high concentration ratio carried, there was insufficient metaphosphate present for effective protection.

3. Probolog Operations. In K-29 two condensers which had been previously probed were reprobed after approximately eleven months' additional service.[1] No increase in frequency or magnitude of pitting was found. A probe of the K-29 steam-heated test condenser also showed no pitting. Two additional condensers, one in K-502-1.10 and one in K-502-1.2, were probed and added to the corrosion control program. In addition to these, there were three used K-29 condensers probed to determine their condition.

In K-31 three new condensers were probed. Two of these were installed (K-602-6.7 and K-602-6.4) and added to the corrosion control program. Seven condensers removed during the ALC program were probed, and five of these were retubed. Also, a probe of the K-31 steam-heated test condenser was made, and no indication of pitting was found.

Two K-33 condensers which had been previously probed prior to installation were reprobed after approximately nineteen months' additional service.[2] No indications of any pitting increase was found. The absence of pitting was confirmed by a probe of the K-33 steam-heated test condenser.

Make-up Water (K-892 A and B)

The slight variance in chemical composition of the make-up water during this report period is indicative of the improvements that have been made to the plant equipment and performance of operational control.

The total make-up water production averaged 18,630 M gallons per day. Lime dosage of 58.5 ppm with 4.9 ppm ferric sulphate reduced the calcium 59.6 per cent (from 84.8 ppm to 34.3 ppm). The turbidity reduction was from 11.5 ppm to 2.7 ppm.

A Loop (K-25 East) and B Loop (K-25 West)

There is evidence of a slight loss in heat transfer characteristics during this report period. The combined "A" and "B" loop pumpage increased 2.5 million gallons per day to 37.5. The "A" loop return water temperature dropped 3° to 117° F, and the "B" loop return water temperature dropped 2.5° to 109° F. The "A" loop average water control valve

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[1] J. L. Gamble, letter to R. N. Rice, entitled "Freon Condenser Corrosion," dated September 8, 1958.

[2] J. L. Gamble, letter to R. L. Newton, entitled "Freon Condenser Corrosion," dated September 8, 1958.

position, as indicated in K-309-2, opened from 45 to 46 per cent open, and the "B" loop average water control valve position, as indicated in K-304-4, opened from 31 to 33 per cent open. A five-megawatt power reduction for the K-25 Cascade aided in preventing further opening of the water control valves. The loss in heat transfer is not primarily attributed to chemical treatment (MarTreat) of the "A" cooling tower for fungi control, as the soluble zinc concentrations were consistently less than 1.0 ppm. Additional heat transfer losses will be counteracted by lowering the loop concentration ratios.

C Loop (K-27/K-29)

The MarTreatment of "C" cooling tower did adversely affect heat transfer during the first half of this report period, as zinc concentrations got as high as 8.24 ppm on August 27; this was due partially to a speed-up of the treatment. Pumpage requirements increased from 41 to a high of 48.5 million gallons per day, and the return water temperature dropped from 132° to 128.5° F. By lowering the concentration ratios, most of the lost heat transfer was recovered by the end of this report period, as the pumpage requirements decreased to 42.5 million gallons per day and the return water temperature increased to 130° F.

A different Orocol (No. 153-H) is now being supplied us by Betz Laboratories, Inc. for "C" loop. This Orocol contains a larger percentage of chromate and will eliminate the necessity for having to supplement the previously used No. 181-H Orocol with additional sodium bichromate. There are at present no plans for dropping the chromate level in "C" loop to the 10-ppm level.

E Loop (K-31)

As with "C" loop, the MarTreatment of the K-31 cooling tower was also responsible for a definite loss of heat transfer. Pumpage requirements increased from 86 to a maximum of 97 million gallons per day, and the return water temperature dropped from 142° to a minimum of 138° F. However, by the end of this report period most of the lost heat transfer characteristics had been recovered, as the required pumpage decreased to 91 million gallons per day and the return water temperature increased to 141° F. Over the entire report period the average water control valve position, as indicated in K-602-3, opened from 41 to 47 per cent open. The highest soluble zinc concentration in the "E" loop recirculating water, as a result of MarTreating the cooling tower, was 7.92 ppm on August 27.

G Loop (K-33)

The heat transfer characteristics of the "G" loop system improved slightly, as indicated by the average closure of the water control

valve position from 78 to 75 per cent open. However, there was no change in the return water temperature; and pumpage increased from 228 to 230 million gallons per day.

Monthly Average Water Analyses

Attached are separate water analyses sheets for July, August, September, and October, 1958. The chemical treatment costs for "C" and "E" loops for July, August, and September were not too representative due to use of Calgon instead of Orocol during portions of these months, since there were often considerable amounts of chromate in the cooling waters from MarTreatment of "C" and "E" cooling towers. Although average analyses are shown for each month, no Poplar Creek water has been used for make-up since July.

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MONTHLY AVERAGE WATER ANALYSES - JULY, 1958

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	216	188	168	413	376	491	433
Metaphosphate as $NaPO_3$	0.19	0.03	0.03	3.71	7.40	8.30	8.71
Orthophosphate as $NaPO_3$	0.54	0.04	0.06	2.69	7.55	12.13	12.19
Total Hardness as $CaCO_3$	111	115	62	216	186	278	228
Calcium as $CaCO_3$	66	70	38	135	93	131	114
M-Alkalinity as $CaCO_3$	73	85	38	42	9	9	8
Turbidity as SiO_2	23.1	16.5	2.8	29.2	5.5	9.5	7.4
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05	0.05-	0.06	0.07	0.05	0.05
Total Iron as Fe	0.49	0.44	0.35	0.44	0.41	0.54	0.48
Sulphate as (SO_4)	12	7	9	103	102	189	154
Zinc as Zn	-	-	-	0.61	2.07	2.79	-
Suspended Solids	12.8	19.2	3.5	14.2	2.7	5.7	3.7
Chromates as CrO_4	-	-	-	-	20.0	20.1	10.1
pH	7.58	8.01	10.12	7.68	6.00	6.00	6.01
Recirculating Water Treatment Used	-	-	-	Calgon, TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$1.262	$1.753	$1.226	$1.196
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	4.91	3.39	3.51

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - AUGUST, 1958

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	155	149	141	220	408	422	392
Metaphosphate as $NaPO_3$	0.03	0.10	0.08	2.32	4.64	5.43	8.42
Orthophosphate as $NaPO_3$	0.26	0.05-	0.06	3.80	6.47	10.10	12.25
Total Hardness as $CaCO_3$	103	116	62	125	194	243	222
Calcium as $CaCO_3$	60	76	31	68	97	124	118
M-Alkalinity as $CaCO_3$	66	84	38	26	10	9	10
Turbidity as SiO_2	16.0	13.1	2.9	9.3	4.9	8.9	10.7
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05	0.05
Total Iron as Fe	1.16	0.60	0.50	0.36	0.35	0.49	0.55
Sulphate as (SO_4)	37	6	8	28	173	147	151
Zinc as Zn	-	-	-	0.30	5.62	4.13	-
Suspended Solids	21.5	22.0	1.7	5.2	2.9	5.0	6.6
Chromates as CrO_4	-	-	-	-	26.6	19.8	11.1
pH	7.00	7.93	10.11	7.60	6.00	6.00	6.03
Recirculating Water Treatment Used	-	-	-	Calgon, TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$1.093	$1.117	$1.105	$1.161
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	3.27	3.15	3.39

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - SEPTEMBER, 1958

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	-	165	149	232	362	322	362
Metaphosphate as $NaPO_3$	0.11	0.05-	0.05-	3.20	5.21	5.35	7.86
Orthophosphate as $NaPO_3$	0.08	0.05-	0.05-	4.61	8.29	9.37	11.35
Total Hardness as $CaCO_3$	158	147	69	198	225	276	257
Calcium as $CaCO_3$	88	90	35	94	106	131	136
M-Alkalinity as $CaCO_3$	40	91	35	26	8	10	8
Turbidity as SiO_2	34	8.5	2.7	9.8	5.3	9.1	6.3
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Total Iron as Fe	0.91	0.58	0.30	0.28	0.34	0.30	0.42
Sulpnate as (SO_4)	30	6	10	33	122	131	136
Zinc as Zn	-	-	-	0.35	5.56	3.10	-
Suspended Solids	-	11	2	3.9	2.5	4.5	3.2
Chromates as CrO_4	-	-	-	-	20.6	21.0	12.2
pH	7.14	7.90	10.13	7.55	6.00	6.00	6.04
Recirculating Water Treatment Used	-	-	-	Calgon, TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$1.013	$1.561	$1.299	$1.186
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	4.78	3.69	3.47

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - OCTOBER, 1958

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	231	131	84	364	250	320	338
Metaphosphate as $NaPO_3$	0.33	0.08	0.05-	3.83	5.77	6.02	8.97
Orthophosphate as $NaPO_3$	0.65	0.06	0.06	6.84	7.20	8.13	9.83
Total Hardness as $CaCO_3$	165	130	74	246	179	223	228
Calcium as $CaCO_3$	111	88	33	114	66	90	95
M-Alkalinity as $CaCO_3$	95	98	30	29	7	8	7
Turbidity as SiO_2	14.5	7.7	2.5	6.3	3.8	5.2	4.4
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05-	0.05-	0.05	0.05-	0.05-	0.05-
Total Iron as Fe	0.46	0.28	0.20	0.30	0.28	0.27	0.27
Sulphate as (SO_4)	54	10	16	85	110	131	156
Zinc as Zn	-	-	-	0.39	1.44	0.95	-
Suspended Solids	11.0	7.8	0.6	4.7	3.8	4.2	3.2
Chromates as CrO_4	-	-	-	-	18.6	20.1	11.2
pH	7.55	7.95	10.11	7.64	6.00	6.00	6.02
Recirculating Water Treatment Used	-	-	-	Calgon, TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.854	$2.176	$1.601	$1.381
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	6.64	4.40	4.04

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

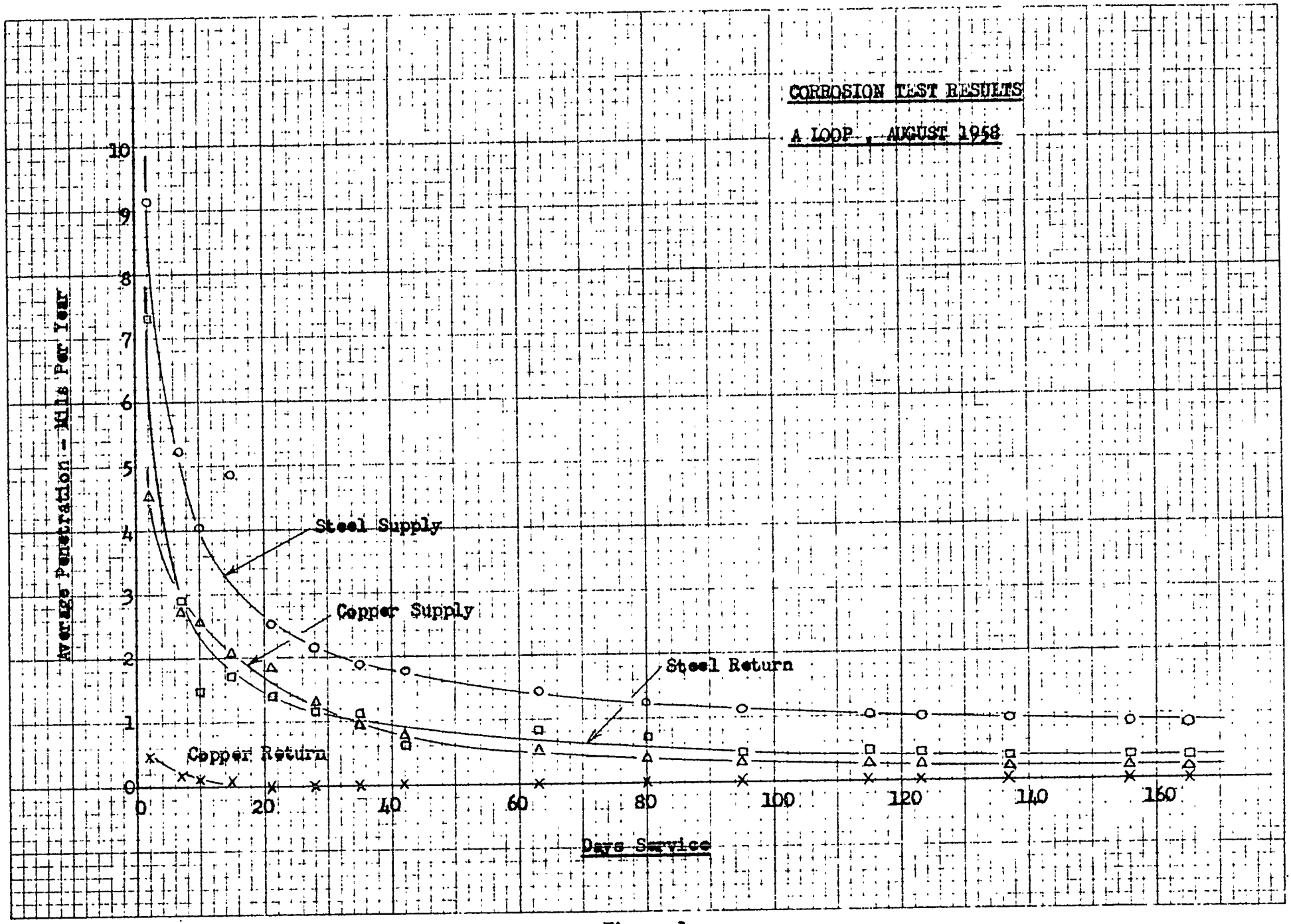

Figure 1

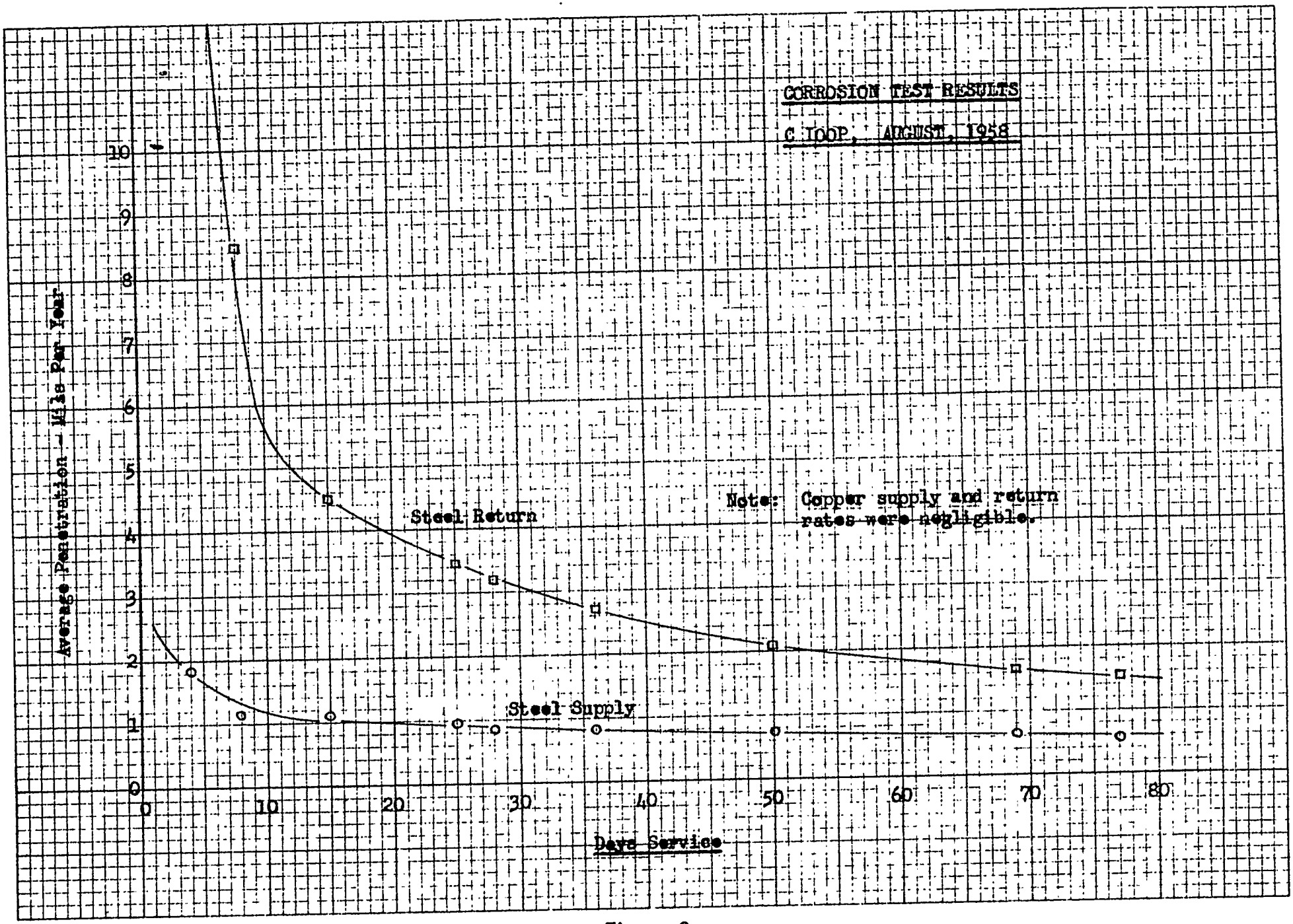

Figure 2

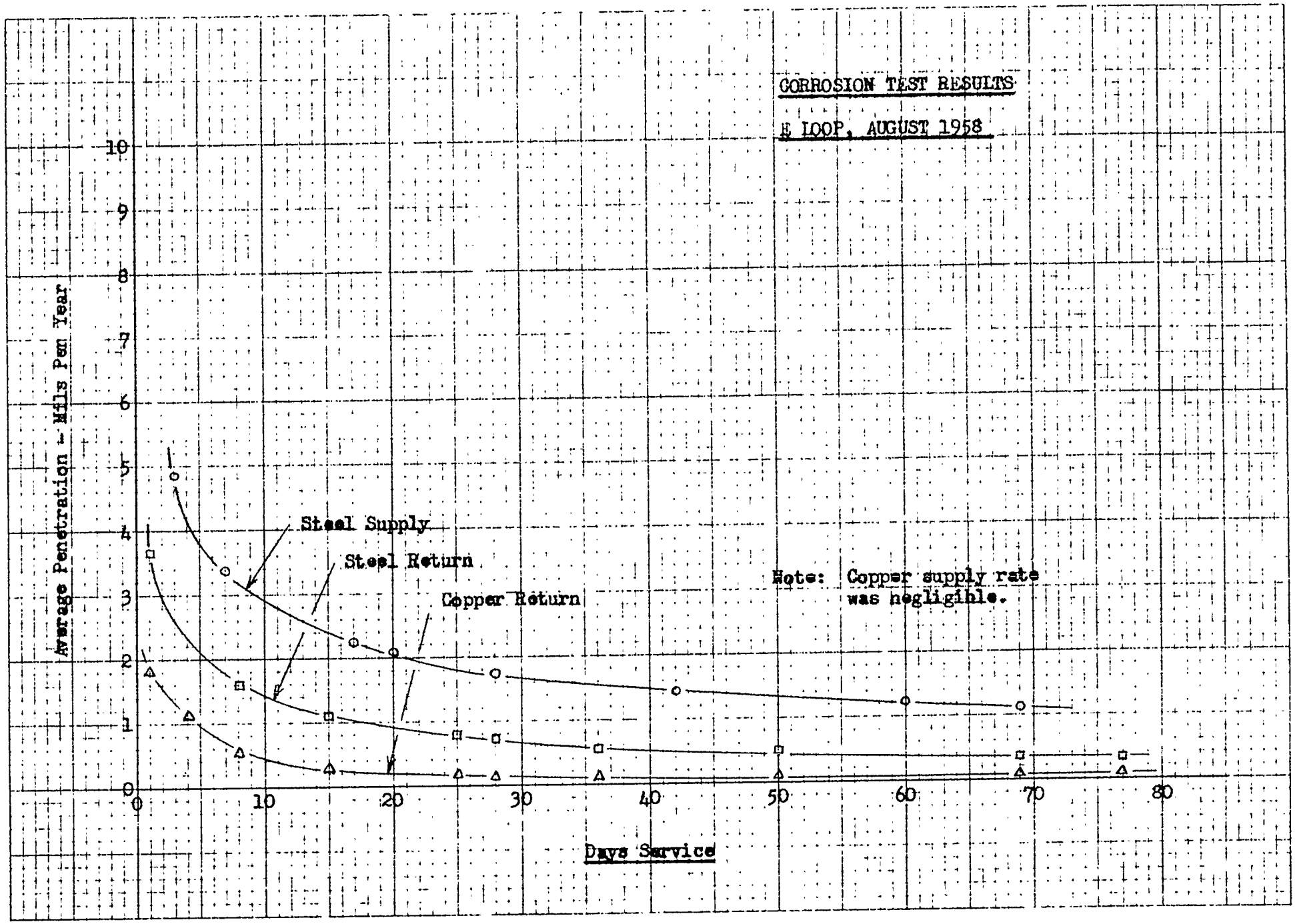

Figure 3

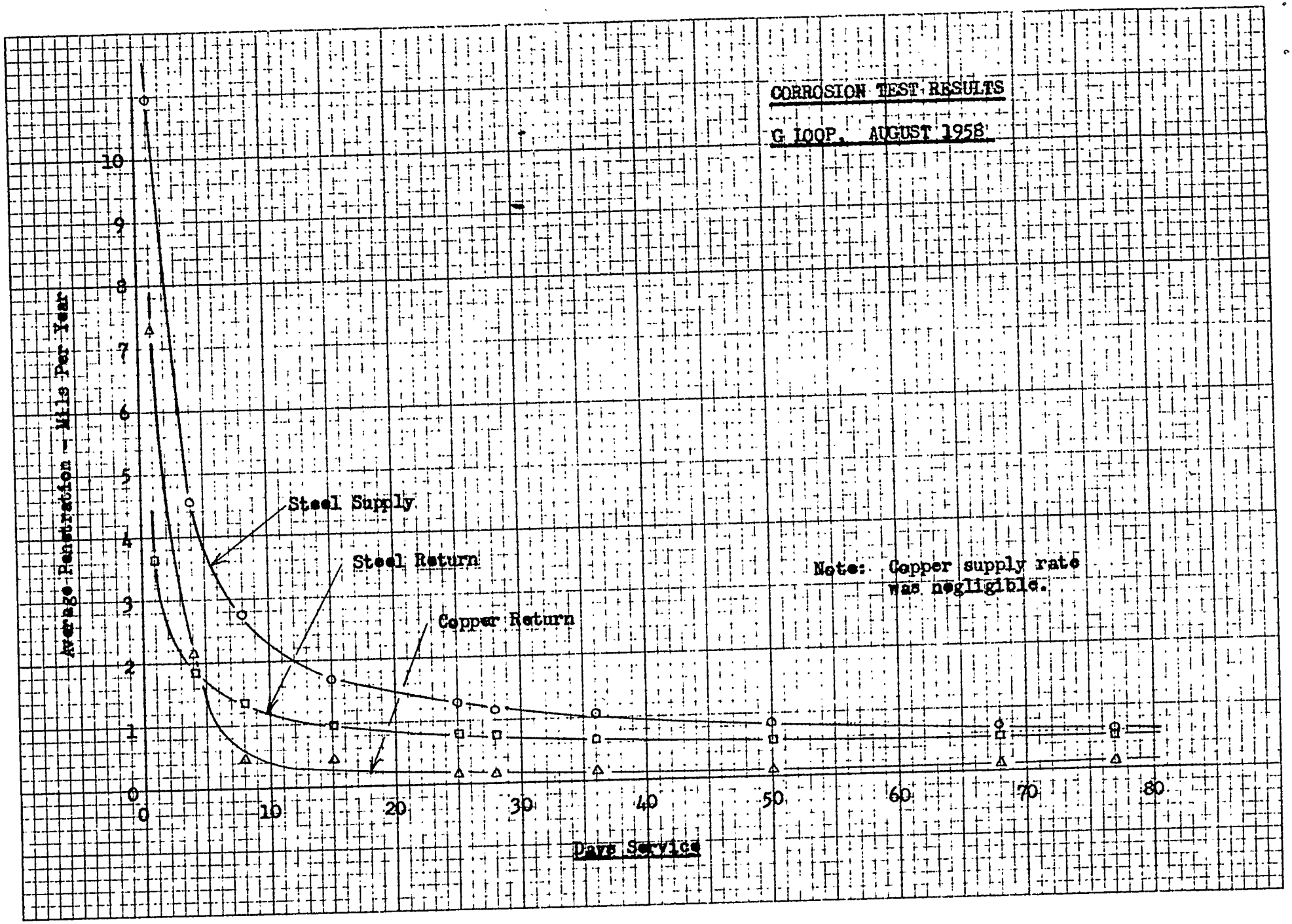

Figure 4

RESULTS OF DEARBORN CORROSION INHIBITOR TEST

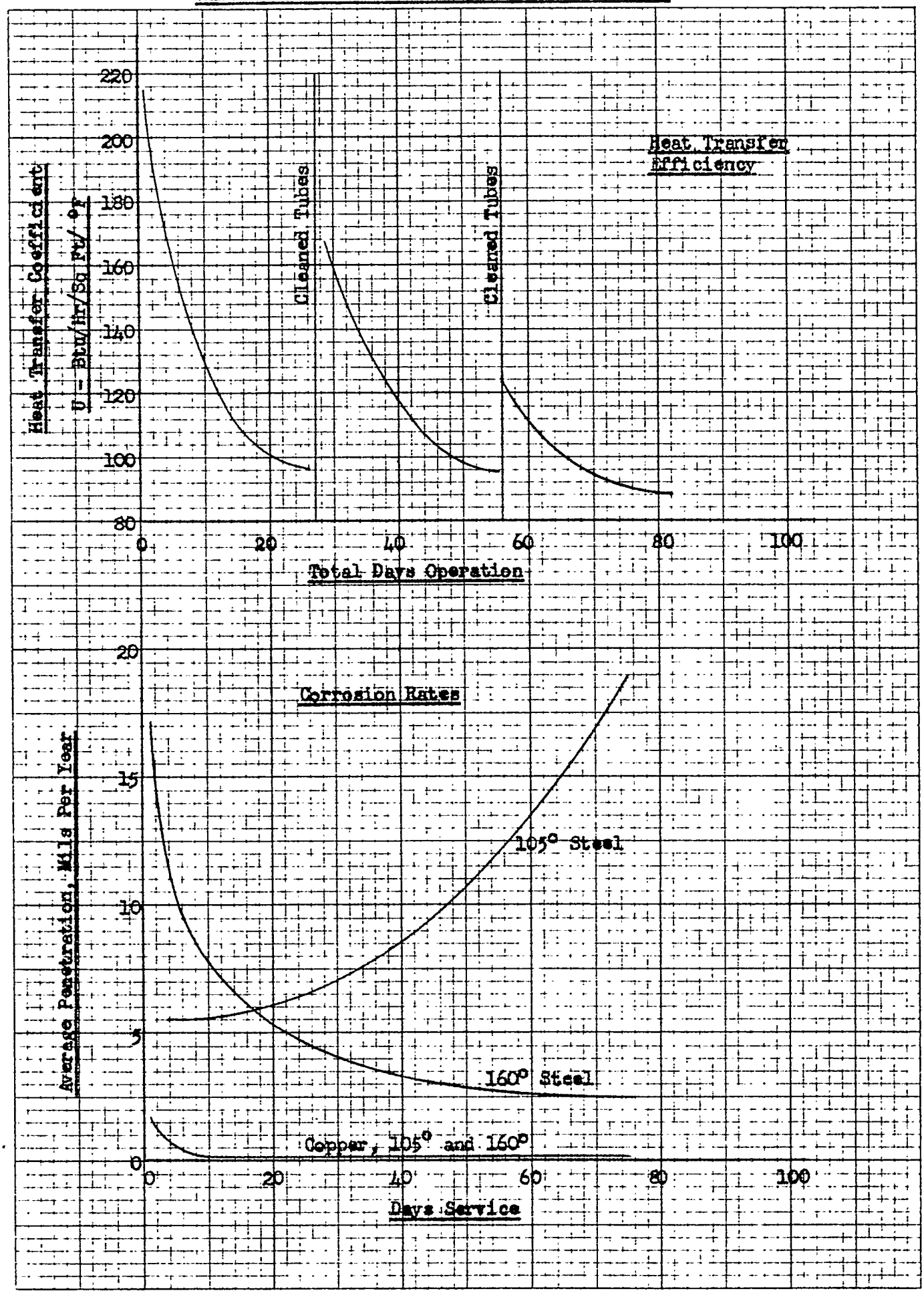

Figure 5

Oct. 22, 1958

Date of Issue: February 4, 1959

Report Number: KP-570
Part No. 31

Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant, Operating Contractor for the U.S. Atomic Energy Commission.

SUMMARY OF RECIRCULATING WATER TREATMENT AND TESTS FOR NOVEMBER AND DECEMBER, 1958

M. A. Fletcher, C. C. Fowlkes,
and J. L. Gamble

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INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

Division of Union Carbide Corporation

To: Mr. H. G. P. Snyder
K-303-7

Plant: ORGDP

Date: February 4, 1959

Copies To: Attached Distribution

Subject: Summary of Recirculating Water Treatment and Tests for November and December, 1958

KP-570, Part No. 31

Summary

This report describes the results of all recirculating water treatment and tests and outlines the results of all recirculating water systems for the months of November and December, 1958.

Corrosion Investigations

1. Corrosion Rates. No changes were noted in corrosion rates for the recirculating water systems from those shown in the last report, all rates being in a satisfactory range.

2. K-892 Test Loop. A ninety-day test of a corrosion inhibitor supplied by National Aluminate Corporation was started. This material is a chromate-type, low-phosphate inhibitor. Its claimed advantage is that higher concentration ratios can be carried in the water system at a pH of 7.0 without excessive deposition or loss of heat transfer, resulting in economy of operation.

   After twelve days of operation at a concentration ratio of 4, no loss of heat transfer has been noted, the copper corrosion rates are negligible, and the steel corrosion rates are below one mil per year. The concentration ratio will be gradually increased to determine the level at which deposition occurs.

3. Probolog Operations. Two condensers which were removed from K-31 for the A-line cooling program were probed. Both were found to be badly pitted, but neither will be retubed until needed. The A-line cooling change-out in K-31 has been completed.

   One spare K-33 condenser was probed. It was found to be in good condition and will be placed in service in K-902-5.3 during the ALC changeover.

   The steam-heated test condenser in K-29 was inspected and no pitting was evident.

A Loop (K-25 East) and B Loop (K-25 West)

The trend toward slight loss of heat transfer characteristics continued during this report period, as the combined "A" and "B" loop pumpage increased 0.5 million gallons per day to 38. The "A" loop return water temperature dropped 1° to 116° F, and the "B" loop return water temperature was constant at 109° F. The "A" loop average water control valve position, as indicated in K-309-2, opened from 46 to 49 per cent open; and the "B" loop average water control valve position, as indicated in K-304-4, was constant at 33 per cent open. With lowered nonreturn usage and firewater pumpage, the "A" and "B" loop concentration ratio has increased to 4.0 and the make-up water requirements are now only about 0.5 million gallons per day as compared to previous requirements of over 2.0 million gallons per day. If necessary, the concentration ratio could be dropped and heat transfer improvements made.

C Loop (K-27/K-29)

A definite improvement in heat transfer characteristics was noted for this report period as zinc concentrations dropped to a range of 1.3 to 1.4 ppm. The return water temperature increased from 130° to 133° F, and pumpage requirements dropped from 42.5 to 41.5 million gallons per day. The K-27 average water control valve position, as indicated in K-402-3, closed from 30 to 29 per cent open. The K-29 average water control valve position, as indicated in K-502-1, closed from 42.5 to 36 per cent open.

E Loop (K-31)

As with "C" loop, there was a definite improvement in heat transfer characteristics as the zinc concentration continued to decrease. There was a large pumpage decrease on December 15 due to a 15-mw power reduction. However, by December 14 pumpage requirements had dropped from 91 to 87.5 million gallons per day, and the average water control valve position, as indicated in K-602-3, had decreased from 47 to 45 per cent open.

G Loop (K-33)

Process heat transfer characteristics improved during this report period. Pumpage decreased from 224 to 202 million gallons per day upon a 120-megawatt-per-day reduction starting December 15 and extending through December 31; but conditions indicating the improvement occurred prior to this operational change.

The loop water was maintained at a concentration of 3.7 cycles, and the phosphate dosage was reduced from 900 to 800 pounds of Orocol No. 179-H

per day. The control valve positions, as indicated in K-902-4, changed from 71 to 61 per cent open; and the water flow was reduced from 230 to 224 million gallons per day.

The chemical treatment cost for this period was the lowest ever experienced in the operation of this facility.

Make-up Water (K-892 A and B)

Make-up water production averaged 18 million gallons per day, requiring a chemical dosage of 63 ppm lime with 4 ppm ferric sulphate to reduce the calcium content from 77 ppm to 30 ppm and the turbidity from 7 to 2 ppm.

Monthly Average Water Analyses

Attached are separate water analyses for November and December, 1958. The chemical treatment costs for "C" and "E" loops are still comparatively high due to lower than normal concentration ratios being maintained to improve heat transfer. The soluble zinc concentrations for "A," "B," "C," and "E" loops continue to decrease.

M. A. Fletcher
M. A. Fletcher

Approved:
W. C. Hartman
W. C. Hartman
Process Utilities Department

C. C. Fowlkes
C. C. Fowlkes

J. L. Gamble
J. L. Gamble

MONTHLY AVERAGE WATER ANALYSES - NOVEMBER, 1958

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	190	123	76	350	255	316	376
Metaphosphate as $NaPO_3$	0.28	0.05-	0.05-	2.59	5.21	6.39	7.89
Orthophosphate as $NaPO_3$	0.70	0.05-	0.05-	6.44	7.16	8.52	11.32
Total Hardness as $CaCO_3$	144	116	57	230	144	172	229
Calcium as $CaCO_3$	87	76	29	116	67	85	107
M-Alkalinity as $CaCO_3$	84	99	34	32	8	8	8
Turbidity as SiO_2	11.8	7.4	2.1	5.1	2.8	3.0	3.1
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05	0.05	0.05	0.05
Copper as Cu - Total	0.05-	0.05-	0.05-	0.06	0.05	0.06	0.06
Total Iron as Fe	0.24	0.15	0.10	0.21	0.18	0.18	0.20
Sulphate as (SO_4)	28	10	19	95	97	131	166
Zinc as Zn	-	-	-	0.29	1.39	0.76	-
Suspended Solids	10.5	8.5	1.7	4.3	2.8	2.8	2.9
Chromates as CrO_4	-	-	-	-	22.1	18.8	10.5
pH	7.9	8.0	10.0	7.7	6.00	6.00	6.00
Recirculating Water Treatment Used	-	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.588	$2.203	$1.725	$1.081
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	6.37	4.68	3.09

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - DECEMBER, 1958

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	280	130	76	393	311	336	404
Metaphosphate as $NaPO_3$	0.13	0.05-	0.05-	2.97	5.59	7.21	7.77
Orthophosphate as $NaPO_3$	0.44	0.05-	0.05-	5.88	8.06	8.20	10.87
Total Hardness as $CaCO_3$	192	132	65	250	176	187	223
Calcium as $CaCO_3$	112	82	32	120	76	88	105
M-Alkalinity as $CaCO_3$	100	98	35	35	8	7	7
Turbidity as SiO_2	6.5	7.8	2.4	5.0	3.3	2.8	3.1
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Total Iron as Fe	0.21	0.19	0.12	0.21	0.18	0.17	0.18
Sulphate as (SO_4)	16	9	18	100	94	131	155
Zinc as Zn	-	-	-	0.12	1.33	0.57	-
Suspended Solids	5.5	7.2	0.5	4.1	3.1	2.8	3.1
Chromates as CrO_4	-	-	-	-	25.0	19.2	10.4
pH	7.5	8.1	10.1	7.7	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.510	$1.932	$1.826	$1.157
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	5.40	4.86	3.30

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

Date of Issue: April 23, 1959

Report Number: KP-570
Part No. 32

SUMMARY OF RECIRCULATING WATER TREATMENT AND TESTS FOR JANUARY, FEBRUARY, AND MARCH, 1959

M. A. Fletcher, C. C. Fowlkes,
and J. L. Gamble

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INTER-COMPANY CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY

Division of Union Carbide Corporation

To: Mr. H. G. P. Snyder
K-303-7

Plant: ORGDP

Date: April 23, 1959

Copies To: Attached Distribution

Subject: Summary of Recirculating Water Treatment and Tests for January, February, and March, 1959

KP-570, Part No. 32

Summary

This report describes the results of all recirculating water treatment tests and summarizes the operation of all recirculating water systems for the first quarter of 1959.

Corrosion Investigations

1. Corrosion Rates. New Corrosometer probes were installed in the supply and return lines for "C" and "E" loops. Orocol No. 153H is now being used in "C" loop and No. 179H in "E" loop. The new probes were installed to determine whether any change occurred in the over-all copper and steel corrosion rates with the change in water treatment. As of the end of this report period, preliminary corrosion rates at seven days were as follows:

	Corrosion Rates, Mils Per Year	
	Supply	Return
"C" Loop		
Copper	1.04	1.04
Steel	0.26	1.30
"E" Loop		
Copper	0	1.88
Steel	1.56	2.09

The tests will be continued to determine the complete corrosion rate curves for each system, but the preliminary data indicate that the rates will be satisfactory.

2. K-892 Test Loop. A sixty-day trial run of the K-892 recirculating water test loop utilizing Nalco 360 corrosion inhibitor was completed.[1] This material is a chromate-type inhibitor and contains

---

[1] J. L. Gamble, letter to W. C. Hartman, entitled "Evaluation of Nalco 360 Corrosion Inhibitor," dated March 3, 1959.

very little phosphate; the manufacturer claimed that the low phosphate content would allow operation at very high concentration ratios without objectionable scale-forming tendencies. The test was run to determine the concentration ratio which could be attained and the associated corrosion rates. The test was run at 7.0 pH with a chromate level of 20 to 24 ppm.

The results of the test are shown on the attached curves. The corrosion rates were good, and a heat transfer coefficient of over 100 Btu/hr/sq ft/^{o}F was maintained up to a concentration ratio of 5.2.

An economic evaluation of Nalco 360 was made at this concentration, and it was found that for "G" loop alone the use of Nalco 360 would result in a cost increase of $13,870 per year. On this basis the material was rejected for use at ORGDP.

3. Probolog Operations. Five K-33 freon condensers were inspected with the Probolog during this report period. Three of these were used condensers replaced during the A-line program in K-33. One of these had a total of eight leaking tubes, one had one leaking tube, the other did not have any leaks. The condition of the condensers inspected to date indicates that the K-33 condensers are in considerably better condition than expected from the results in K-31, and that a complete condenser retubing program may not be necessary for K-33. The other two K-33 condensers inspected were retubed units scheduled for installation during the ALC program.

   The steam-heated test condenser in K-31 was probed during this report period and no indications of pitting were found. It was necessary to replace the shell on this unit, however, due to corrosion from the condensate.

   A small condenser removed from the K-633 test loop was also probed. It is scheduled to be installed as a replacement for the unit in the K-29 "A" booster station.

A Loop (K-25 East) and B Loop (K-25 West)

The previous trend toward loss of heat transfer characteristics was reversed during this quarter, as the return water temperatures increased and the water control valves closed despite a power increase. More specifically, the "A" loop return water temperature increased 2^{o} to 118^{o} F and the "B" loop return water temperature increased 3^{o} to 112^{o} F. The "A" loop average water control valve position, as indicated in K-309-2, closed from 49 to 45 per cent open, and the "B" loop average water control valve position, as indicated in K-304-4, closed from 33 to 32.5 per cent open.

On March 10, a power load increase of 18 mw in K-25 resulted in a total pumpage increase of 6 million gallons per day to 44. This power increase was part of a total plant increase of 75 mw due to load reduction at Y-12.

C Loop (K-27/K-59)

The total pumpage requirements for "C" loop increased from 41.5 to 45.5 million gallons per day as a result of the March 10 power increase. About 15 mw was picked up in K-27, while K-29 was allotted only a 2-mw increase. The K-27 average water control valve position increased from 29 to 33 per cent open, which is certainly not out of line with the power increase. There are indications of definite loss of heat transfer in K-29, where the average water control valve position, as indicated in K-502-1, increased from 36 to 53.5 per cent open. The heat transfer loss in K-29 is attributed to maintaining a concentration ratio of about 4 instead of the usual range of 2.5 to 3.0. Decreased nonreturn usage allowed reductions in make-up water requirements which resulted in the higher-than-normal concentration ratio. This condition will be watched very closely, and the concentration ratio will be lowered by adding additional make-up water if necessary. The attached monthly average water analyses sheet for March shows that the "C" loop total dissolved solids, calcium hardness, and total hardness are higher than those of any other loops.

E Loop (K-31)

There are indications of definite improvement in heat transfer during this report period, as the water control position, as indicated in K-602-3, closed from 45 to 39.5 per cent open, despite a power increase of 5 mw. There was no appreciable change in either the pumpage requirements or the return water temperature.

On January 7, the recirculating water treatment was changed from Orocol No. 181H to Orocol No. 179H, as the latter treatment has proven very successful in K-33. This change in treatment will result in reducing the chromate concentration to 10 ppm. Despite good results in K-33 at the lower chromate level, there had previously been some reluctance to extending this treatment to K-31 while new condensers were being placed in initial service.

The last of the original K-31 condensers was replaced in November, 1958, giving every new condenser at least five to six weeks' service at the higher chromate level before changing the chemical treatment.

Decreasing the chromate concentration in "E" loop will result in a savings of approximately $7,200 per year in water treatment costs.

G Loop (K-33)

All data indicate that the "G" loop system improved in heat transfer characteristics: pumpage decreased from 230 to 222 million gallons per day, return water temperature increased 0.2 degree to 147.6° F., and control valve positions averaged a 2.3-per-cent closure to 72.7 per cent.

Make-up Water (K-892 A and B)

Heavy rainfall during this three-month period created very adverse conditions for water softening operations.

An average of 17,704 M gallons per day was treated. The lime requirement was 59.0 ppm with a 12.5-ppm ferric sulfate dosage. The treatment reduced turbidity from 46.5 to 7.3 ppm and the calcium hardness from 76.3 to 45.2 ppm (a 40.8-per-cent calcium reduction).

An organic polyelectrolyte known as Hagan Aid No. 50 was used at a dosage of 0.1 ppm to aid coagulation during only one week of this period. Plant results were greatly improved by the use of this material.

Monthly Average Water Analyses

Attached are separate water analyses sheets for January, February, and March, 1959. It will be noted that the "E" loop chromate concentration decreased to the range of 10 to 12 ppm, and that the water treatment costs for this system decreased appreciably with the change in water treatment. As previously noted, the "C" loop concentration ratios are much higher than usual; in fact, the March values are the highest ever recorded for this loop.

M. A. Fletcher
M. A. Fletcher

Approved:

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C. C. Fowlkes
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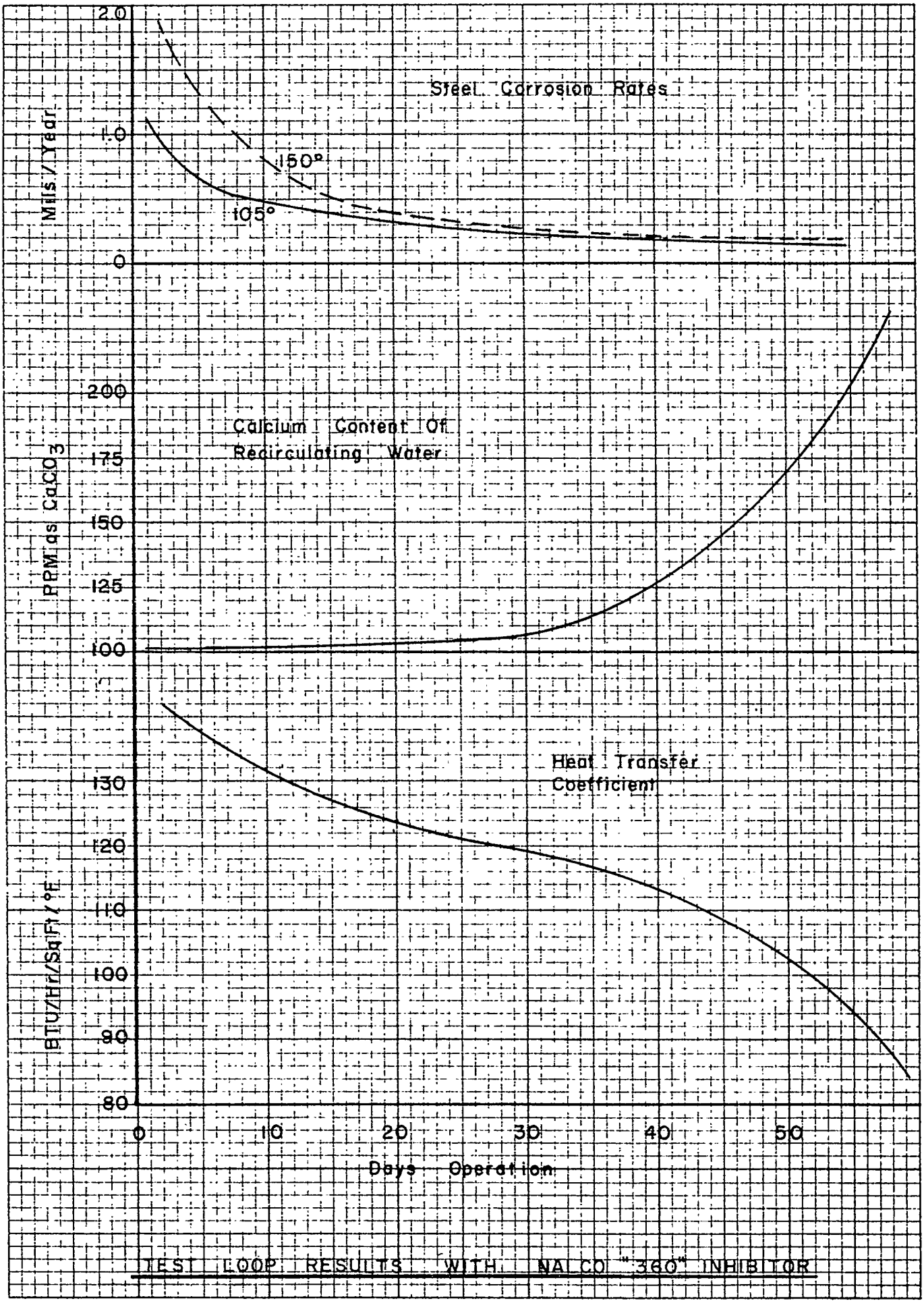

TEST LOOP RESULTS WITH NALCO "360" INHIBITOR

MONTHLY AVERAGE WATER ANALYSES - JANUARY, 1959

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	173	149	106	349	374	374	438
Metaphosphate as $NaPO_3$	0.08	0.05-	0.05-	2.54	4.46	6.24	5.94
Orthophosphate as $NaPO_3$	0.34	0.05-	0.05-	5.82	8.59	8.02	9.58
Total Hardness as $CaCO_3$	129	115	82	218	214	224	266
Calcium as $CaCO_3$	84	77	48	112	117	127	152
M-Alkalinity as $CaCO_3$	64	88	38	33	8	8	8
Turbidity as SiO_2	18	74	13	12	21	40	45
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05-	0.05-	0.06	0.06	0.05	0.05
Total Iron as Fe	0.24	0.23	0.12	0.17	0.22	0.18	0.17
Sulphate as (SO_4)	56	14	34	154	175	182	224
Zinc as Zn	-	-	-	0.10	1.13	0.42	-
Suspended Solids	14.2	55.8	3.0	9.5	15.8	33.3	37.9
Chromates as CrO_4	-	-	-	-	20.2	13.1	10.2
pH	7.8	8.0	10.0	7.7	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.516	$1.662	$1.590	$1.332
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	4.73	4.16	3.81

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - FEBRUARY, 1959

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	124	158	97	371	436	336	447
Metaphosphate as $NaPO_3$	0.07	0.05-	0.05-	2.29	3.52	5.05	5.10
Orthophosphate as $NaPO_3$	0.31	0.05-	0.05-	3.65	8.16	10.56	10.47
Total Hardness as $CaCO_3$	79	113	68	238	248	231	266
Calcium as $CaCO_3$	55	75	41	138	162	150	178
M-Alkalinity as $CaCO_3$	38	84	34	47	12	15	7
Turbidity as SiO_2	18	38	6	15	30	45	56
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05	0.05	0.05
Copper as Cu - Total	0.05-	0.05-	0.05-	0.06	0.05	0.06	0.06
Total Iron as Fe	0.15	0.16	0.12	0.17	0.17	0.17	0.17
Sulphate	38	14	19	147	184	185	202
Zinc as Zn	-	-	-	0.05	1.04	0.29	-
Suspended Solids	10	58	8	10	21	37	46
Chromates as CrO_4	-	-	-	-	22.3	10.5	10.2
pH	8.8	8.0	10.1	8.1	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.484	$1.620	$1.544	$1.255
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	4.61	3.96	3.64

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - MARCH, 1959

P.P.M.	Poplar Creek	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	174	139	96	344	473	427	427
Metaphosphate as $NaPO_3$	0.05-	0.05-	0.05-	2.58	4.15	7.16	6.54
Orthophosphate as $NaPO_3$	0.19	0.05-	0.05-	4.45	8.68	11.78	11.38
Total Hardness as $CaCO_3$	96	111	70	226	266	249	253
Calcium as $CaCO_3$	66	75	45	133	158	132	144
M-Alkalinity as $CaCO_3$	51	84	30	39	9	7	7
Turbidity as SiO_2	12	41	5	11	16	17	18
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05-	0.05-	0.05-	0.05-	0.05	0.05
Total Iron as Fe	0.13	0.12	0.11	0.19	0.19	0.18	0.19
Sulphate as (SO_4)	34	15	22	151	193	189	204
Zinc as Zn	-	-	-	-	0.83	0.31	-
Suspended Solids	8.0	45.4	3.1	7.2	10.7	11.9	12.4
Chromates as CrO_4	-	-	-	-	26.0	11.5	11.3
pH	8.1	8.0	10.1	7.8	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	-	$0.511	$1.629	$1.503	$1.358
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	-	4.67	3.88	3.94

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

Date of Issue: August 31, 1959

Report Number: KP-570
Part No. 33

SUMMARY OF RECIRCULATING WATER TREATMENT AND TESTS FOR APRIL, MAY, AND JUNE, 1959

M. A. Fletcher, C. C. Fowlkes,
and J. L. Gamble

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UNION CARBIDE NUCLEAR COMPANY
OAK RIDGE GASEOUS DIFFUSION PLANT
Production Division
Process Utilities Department

UCN-428
(1 1-59)

UNION CARBIDE INTERNAL CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY • POST OFFICE BOX P OAK RIDGE TENNESSEE

To (Name) Mr. H. G. P. Snyder
Company UCNC ORGDP
Location K-303-7

Date August 31, 1959
Originating Dept. Utilities
Answering letter date

Copy to Attached Distribution

Subject Summary of Recirculating Water Treatment and Tests for April, May, and June, 1959

KP-570, Part No. 33

Summary

This report describes the results of all recirculating water treatment tests and the operation of all recirculating water systems for the second quarter of 1959.

Corrosion Investigations

1. Corrosion Rates. Corrosometer data were accumulated to determine new corrosion rate curves for "C" and "E" loops subsequent to the changes in water treatment in these loops. The results of these tests are shown on the attached curves, Figures 1 and 2.

   In comparing the corrosion rate curves for these loops with corrosion rates obtained prior to the change in water treatment, it is noted that no significant change has occurred in the over-all corrosion rates. The slight differences in individual rates are within the limits of accuracy of the procedure used. All results are considered satisfactory.

Probolog Operations

1. K-29. Condenser 215700 in K-502-3.6 was reprobed after approximately eighteen months' service. This condenser had been probed twice previously, once prior to installation. No indications of any pitting were found.

   Condenser 215707 was removed from K-502-2.1 due to freon leakage. It was probed and severe pitting was found. It was recommended that this condenser be retubed.

2. K-31. Condenser 242700 was inspected with the Probolog during an outage for a scheduled power reduction. This condenser, probed prior to installation in K-602-1.2 on October 30, 1957, thus has had approximately twenty months' service under A-line cooling conditions. No indications of any pitting were found.

3. K-33. A total of five K-33 condensers were probed during this report period. Two of these were removed during the change to A-line cooling and found to be pitted moderately. Two of the condensers were retubed units scheduled for installation in K-33. The remaining unit, in K-902-3.8 odd, was an original installation and was probed for addition to the corrosion monitoring program. This condenser was in surprisingly good condition for an original installation.

4. K-892. The steam-heated test condenser in the K-892 pumphouse was inspected with the Probolog and no indications of pitting were found.

A Loop (K-25 East) and B Loop (K-25 West)

There were no significant changes in heat transfer characteristics during this quarter, as both return water temperatures remained unchanged. The combined pumpage requirements increased from 44 to 46 million gallons per day.

The "A" loop coverage water control valve position, as indicated in K-309-2, was unchanged at 45 per cent open, and the "B" loop average water control valve position, as indicated in K-304-4, opened from 32.5 to 35 per cent open.

C Loop (K-27/K-29)

There was no net change in the "C" loop heat transfer characteristics during this quarter, as the pumpage was constant at 45.5 million gallons per day and the return water temperature was unchanged at 132° F.

There are indications of improvement in heat transfer in K-29, where the average water control valve position, as indicated in K-502-1, closed from 53.5 to 49.5 per cent open. There are indications of loss of heat transfer in K-27, where the average water control valve position, as indicated in K-402-3, opened from 33 to 39 per cent open.

E Loop (K-31)

During this quarter there was little change in either the pumpage requirements (up one million to 84.5 million gallons per day) or the return water temperature (up 1.5° F to 144° F); however, the average water control valve position, as indicated in K-602-3, opened from 39.5 to 50.5 per cent open. It is believed that a transfer of 5 mw power load to unit 3 accounted for the opening of the water control valves rather than an appreciable loss of heat transfer. The total power increase for all K-31 during this quarter was 3 mw.

G Loop (K-33)

The average "G" loop pumpage increased from 222 to 231 million gallons per day, return water temperature decreased 1.1 degrees to 146.5° F, and control valves

opened another 1.5 per cent to a position of 74.2 per cent open. The heat load increased 1.2 per cent during this period, and the heat transfer characteristics indicate that improvement has been made during the month of June. Orocol dosage was reduced 100 pounds per day during the month of June, and the phosphate and chromate concentrations were maintained within the control limits.

Make-up Water (K-892-A and B)

Make-up water production increased 5.4 per cent to an average of 18,654 M gallons per day. Treatment dosages were reduced as compared with last quarter, and the quality of the effluent was improved. Fifty-two ppm lime and 9.2 ppm ferric sulphate reduced turbidity from 32.3 to 3.4 ppm and reduced calcium hardness 52.8 per cent from 77.6 to 36.6 ppm.

Hagan Aid No. 50 was discontinued during this period, which also contributed to the lower production cost.

Monthly Average Water Analyses

Attached are separate water analyses sheets for April, May, and June, 1959. As shown in previous reports, the "C" loop concentration, as indicated by the dissolved solids and total hardness, continues somewhat higher than that maintained on "E" and "G" loops. Operation of "C" loop at a lower phosphate residual than the other high temperature systems undoubtedly contributes to the ability to maintain higher concentration ratios. There was a general reduction on all water treatment costs as compared with the previous quarter due to lower make-up water costs.

M. A. Fletcher

Approved:

W. C. Hartman
Utilities Department

C. C. Fowlkes

J. L. Gamble

MONTHLY AVERAGE WATER ANALYSES - APRIL, 1959

P.P.M.	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	136	78	385	450	384	408
Metaphosphate as $NaPO_3$	0.05-	0.05-	2.26	3.52	6.38	5.32
Orthophosphate as $NaPO_3$	0.05-	0.05-	5.41	8.13	10.62	11.38
Total Hardness as $CaCO_3$	108	62	244	256	221	240
Calcium as $CaCO_3$	77	42	154	166	138	150
M-Alkalinity as $CaCO_3$	78	33	29	9	7	8
Turbidity as SiO_2	43	5.2	15	22	24	30
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Total Iron as Fe	0.15	0.11	0.18	0.18	0.18	0.18
Sulphate as (SO_4)	12	23	155	192	190	201
Zinc as Zn	-	-	-	0.76	0.29	-
Suspended Solids	28.5	0.5	8.3	13.2	14.6	21.4
Chromates as CrO_4	-	-	-	24.4	11.2	10.8
pH	7.8	10.0	7.7	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$0.448	$1.336	$1.338	$1.205
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	3.94	3.52	3.52

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - MAY, 1959

P.P.M.	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	173	131	427	488	422	419
Metaphosphate as PO_4	0.05-	0.05-	2.45	4.85	9.92	8.09
Orthophosphate as PO_4	0.05-	0.05-	6.25	8.89	10.28	11.00
Total Hardness as $CaCO_3$	114	60	231	247	208	234
Calcium as $CaCO_3$	78	33	138	124	97	112
M-Alkalinity as $CaCO_3$	85	34	27	8	8	7
Turbidity as SiO_2	22	2.5	10	11	10	11
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05	0.05	0.06	0.05	0.06
Total Iron as Fe	0.12	0.12	0.18	0.16	0.17	0.17
Sulphate as (SO_4)	12	21	158	188	174	196
Zinc as Zn	-	-	-	1.00	0.17	-
Suspended Solids	7.0	0.6	5.6	6.4	5.9	6.9
Chromates as CrO_4	-	-	-	23.0	11.4	10.9
pH	8.1	9.9	7.7	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$0.448	$1.303	$1.289	$1.104
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	3.68	3.43	3.22

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - JUNE, 1959

P.P.M.	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	148	85	416	545	416	436
Metaphosphate as PO_4	0.05-	0.05-	2.08	4.44	8.72	7.72
Orthophosphate as PO_4	0.05	0.05	6.36	8.30	10.05	10.51
Total Hardness as $CaCO_3$	122	64	247	282	226	242
Calcium as $CaCO_3$	87	39	142	166	125	126
M-Alkalinity as $CaCO_3$	86	34	29	8	9	7
Turbidity as SiO_2	18.5	23.3	13	18	10	11
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Total Iron as Fe	0.17	0.09	0.11	0.11	0.14	0.11
Sulphate as (SO_4)	15	16	126	188	146	163
Zinc as Zn	-	-	-	0.80	0.18	-
Suspended Solids	13.2	0.5	6.9	11.8	5.7	6.6
Chromates as CrO_4	-	-	-	23.3	10.6	10.3
pH	7.9	9.9	7.7	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$0.468	$1.363	$1.354	$1.194
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	3.79	3.29	3.60

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

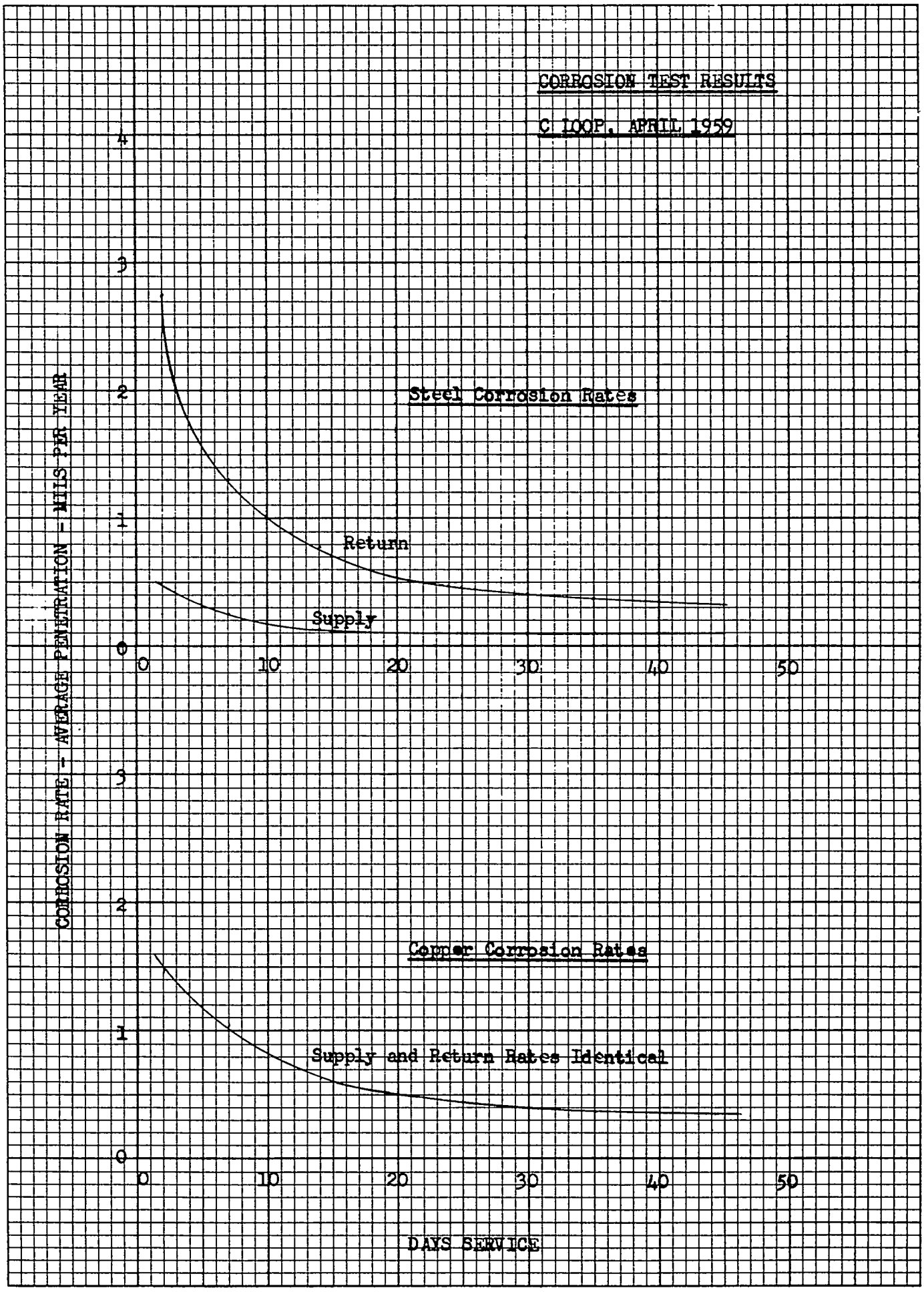
CORROSION TEST RESULTS
C LOOP, APRIL 1959
CORROSION RATE - AVERAGE PENETRATION - MILS PER YEAR
Steel Corrosion Rates
Return
Supply
Copper Corrosion Rates
Supply and Return Rates Identical
DAYS SERVICE
0
1
2
3
4
10
20
30
40
50

Figure 1

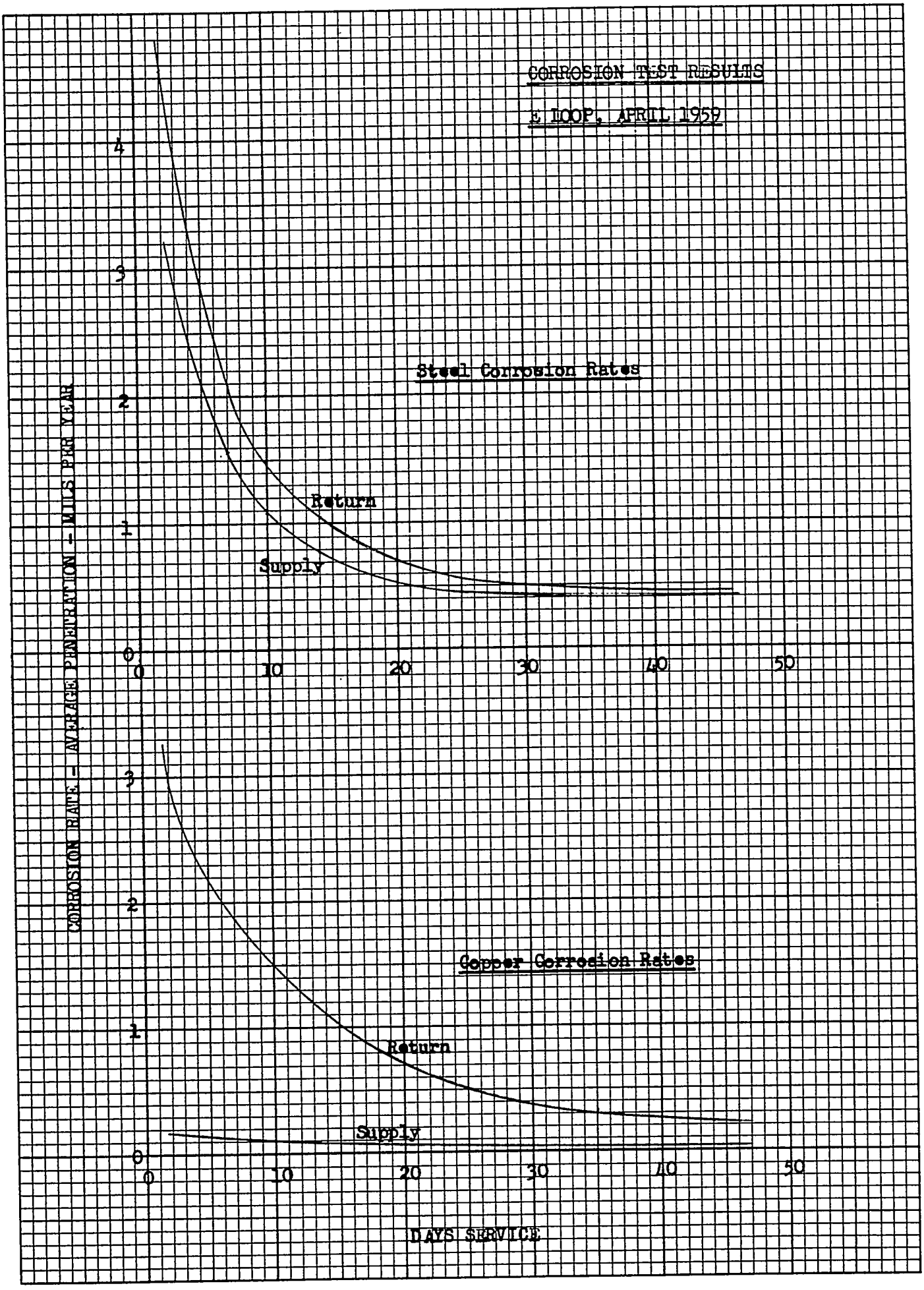
CORROSION TEST RESULTS
E LOOP, APRIL 1959
Steel Corrosion Rates
Return
Supply
Copper Corrosion Rates
Return
Supply
CORROSION RATE = AVERAGE PENETRATION - MILS PER YEAR
DAYS SERVICE
0
1
2
3
4
10
20
30
40
50

Figure 2

Date of Issue: December 9, 1959

Report Number: KP-570
Part No. 34

SUMMARY OF RECIRCULATING WATER TREATMENT AND TESTS FOR JULY, AUGUST, AND SEPTEMBER, 1959

M. A. Fletcher, C. C. Fowlkes,
and J. L. Gamble

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OAK RIDGE GASEOUS DIFFUSION PLANT
Production Division
Utilities Operations Department

UCN-428
(1 1-59)

UNION CARBIDE INTERNAL CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY • POST OFFICE BOX P, OAK RIDGE, TENNESSEE

To (Name) Mr. H. G. P. Snyder
Company UCNC ORGDP
Location K-303-7

Date December 9, 1959

Originating Dept. Utilities Operations

Answering letter date

Copy to Attached Distribution

Subject Summary of Recirculating Water Treatment and Tests for July, August, and September, 1959

KP-570, Part No. 34

Summary

This report describes the results of all recirculating water treatment tests and the operation of all recirculating water systems for the third quarter of 1959.

Corrosion Results

There were no significant changes noted in corrosion rates for any of the recirculating water systems. No evidence of any new copper pitting or progress of pitting in old condensers has been detected since changing to the dianodic type treatment.

One K-33 condenser, in K-902-7.10 east, was inspected with the Probolog. This particular condenser has been in service for three and one-half years, on dianodic treatment only, and no indication of any pitting attack was found.

A Loop (K-25 East) and B Loop (K-25 West)

There does not appear to be any significant changes in heat transfer characteristics during this quarter, as pumpage requirements and return water temperatures decreased as expected with a 14 mw load reduction. The total pumpage requirements dropped from 48 to 45 million gallons per day, and the return water temperature for both loops dropped 2° to 116 and 110° F.

The water control valve positions, as indicated in K-309-2 and K-304-4, were practically unchanged during this quarter.

C Loop (K-27/K-29)

The "C" loop total pumpage requirements dropped from 45.5 to 37.5 million gallons per day following a power reduction of 23 mw. As all the power

reduction occurred in K-27, the higher K-29 return water temperature now represents a larger percentage of the total "C" loop flow, and the total "C" loop return water temperature increased 3° to 135° F.

Apparently there was some loss in heat transfer characteristics, at least in K-29, where the water control valve position, as indicated in K-502-1, opened from 49.5 to 55.0 per cent open. This indicated loss of heat transfer occurred in September when the loop concentration ratio was considerably higher than normal. This ratio will be reduced to regain loss in heat transfer.

The K-27 water control positions, as indicated in K-402-3, show a slight loss of heat transfer characteristics after the load reduction in mid-August, as the valves opened from 31 to 33 percent open by the end of September.

E Loop (K-31)

Due to a 34 mw power reduction in K-31, the pumpage requirements dropped from 84.5 to 75.0 million gallons per day and the water control valve positions, as indicated in K-602-3, closed from 50.5 to 38.5 percent open.

As the return water temperature increased 1° to 145° F, it is believed that there was little change in K-31 heat transfer characteristics during this report period.

G Loop (K-33)

On August 16 a 15 mw load reduction decreased pumpage from 231 to 213 MGPD or 18 million gallons per day; return water temperature dropped 2°, from 146 to 144° F, and average control valve positions changed from 74 to 71 percent open.

By the end of September, pumpage had increased to 220 MGPD though return water temperature and control valve positions remained unchanged. This increased pumpage without any power load increase is indicative of some loss in heat transfer characteristics.

Make-up Water (K-892-A and B)

Some improvement was made in make-up water quality as noted in the table below:

	This Quarter	Last Quarter
Production, MGPD	17,874	18,654
Chemical Analysis, PPM		
Turbidity		
Raw	16.4	32.3
Finished	2.4	3.4
Calcium Hardness		
Raw	80.4	77.6
Finished	34.6	36.6

	This Quarter	Last Quarter
Chemical Treatment, PPM		
Lime	54.7	52.0
Ferric Sulphate	4.9	9.2

Monthly Average Water Analyses

Attached are separate water analyses sheets for July, August, and September, 1959.

M. A. Fletcher

Approved:

W. C. Hartman
Utilities Operations Department

C. C. Fowlkes

J. L. Gamble

MONTHLY AVERAGE WATER ANALYSES - JULY, 1959

P.P.M.	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	142	86	345	412	385	487
Metaphosphate as $NaPO_3$	0.05-	0.05-	1.51	4.67	8.64	8.34
Orthophosphate as $NaPO_3$	0.05-	0.05-	5.72	6.23	9.01	12.18
Total Hardness as $CaCO_3$	120	61	210	192	216	258
Calcium as $CaCO_3$	84	34	115	114	108	152
M-Alkalinity as $CaCO_3$	90	32	32	8	9	8
Turbidity as SiO_2	15.7	2.3	7	6	7	7
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Total Iron as Fe	0.10	0.08	0.07	0.07	0.06	0.07
Sulphate as SO_4	10	18	78	112	100	161
Zinc as Zn	-	-	-	0.86	0.16	-
Suspended Solids	13.0	0.5	4.7	4.1	4.8	5.0
Chromates as CrO_4	-	-	-	20.3	10.4	11.5
pH	8.1	9.8	7.7	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$0.490	$1.515	$1.374	$1.145
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	4.36	3.52	3.46

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - AUGUST, 1959

P.P.M.	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	129	84	342	433	379	443
Metaphosphate as $NaPO_3$	0.05-	0.05-	1.65	3.63	8.48	7.42
Orthophosphate as $NaPO_3$	0.05	0.05	6.23	7.10	9.03	10.91
Total Hardness as $CaCO_3$	115	67	214	232	210	275
Calcium as $CaCO_3$	82	39	118	131	119	149
M-Alkalinity as $CaCO_3$	92	35	28	9	8	8
Turbidity as SiO_2	20	3	6	9	9	11
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Total Iron as Fe	0.06	0.05	0.04	0.05	0.04	0.04
Sulphate as SO_4	12	15	89	147	121	127
Zinc as Zn	-	-	-	0.90	0.17	-
Suspended Solids	8.6	1.1	3.1	4.6	4.8	6.7
Chromates as CrO_4	-	-	-	20.9	10.2	10.2
pH	7.9	9.8	7.7	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$0.483	$1.503	$1.443	$1.129
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	4.09	3.71	3.44

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - SEPTEMBER, 1959

P.P.M.	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	141	82	327	448	341	422
Metaphosphate as $NaPO_3$	0.05-	0.05-	1.75	3.42	7.35	6.73
Orthophosphate as $NaPO_3$	0.05-	0.05-	6.05	8.04	9.41	11.01
Total Hardness as $CaCO_3$	118	59	210	266	203	254
Calcium as $CaCO_3$	85	32	118	159	117	141
M-Alkalinity as $CaCO_3$	94	34	32	9	8	8
Turbidity as SiO_2	11.0	1.5	7	8	6	6
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Total Iron as Fe	.09	.08	.08	.08	.07	.07
Sulphate as SO_4	14	19	92	158	115	150
Zinc as Zn	-	-	-	0.64	0.12	-
Suspended Solids	7.4	0.5-	8.2	4.9	3.6	3.5
Chromates as CrO_4	-	-	-	23.6	10.2	10.4
pH	7.9	9.6	7.7	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$0.462	$1.603	$1.626	$1.198
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	4.16	3.99	3.73

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

Date of Issue: February 5, 1960

Report Number: KP-570
Part No. 35

SUMMARY OF RECIRCULATING WATER TREATMENT AND TESTS FOR OCTOBER, NOVEMBER, AND DECEMBER, 1959

M. A. Fletcher, C. C. Fowlkes,
and J. L. Gamble

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UNION CARBIDE NUCLEAR COMPANY
OAK RIDGE GASEOUS DIFFUSION PLANT
Production Division
Utilities Operations Department

UCN-428
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UNION CARBIDE INTERNAL CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY • POST OFFICE BOX P. OAK RIDGE, TENNESSEE

To (Name) Mr. H. G. P. Snyder
Company UCNC ORGDP
Location K-303-7

Date February 5, 1960

Originating Dept. Utilities Operations

Answering letter date

Copy to Attached Distribution

Subject Summary of Recirculating Water Treatment and Tests for October, November, and December, 1959

KP-570, Part No. 35

Summary

This report describes the results of all recirculating water treatment tests and the operation of all recirculating water systems for the fourth quarter of 1959.

Condenser Inspections

The freon condenser in K-602-6.10 was removed from service due to excessive leakage. Upon inspection, numerous tube sheet leaks were found, but visual and Probolog inspections of the tubes were made and no indications of any pitting could be detected.

One K-29 condenser, removed from K-502-3.5, was inspected with the Probolog. This was an original K-29 tube bundle, but upon inspection was found to be considerably better than the average K-29 condensers. This tube bundle was acid cleaned and retained as a spare unit.

The steam heated test condenser in K-29 was inspected with the Probolog, and no indications of any pitting were found. Most of the tubes in this condenser have now been in service for over two years under conditions closely approximating the freon condenser conditions.

A Loop (K-25 East) and B Loop (K-25 West)

The combined "A" and "B" loop pumpages increased from 45 to 47.5 million gallons per day as a result of a power increase of 5 mw. Some load shifting also occurred as a result of shutting down the three top units (K-305-10, 11, and 12).

The increased pumpage was picked up on the "A" loop side in conjunction with a 6 mw power increase while the "B" loop section dropped one mw.

The "A" loop return water temperature was constant at 116° F, and the "B" loop return water temperature dropped 2° to 109° F.

The "A" loop water control valve positions as indicated in K-309-2 was unchanged at 46.5 percent open while the "B" loop water control valve positions as indicated in K-304-4 opened from 35 to 37.5 percent open. However, the K-304 section was not typical of the "B" section as a 1.5 mw load increase occurred there despite the over-all load reduction.

Changing conditions prevent accurate estimate of any small changes in heat transfer characteristics, but it appears that there has been no large changes during this report period.

The water treatment costs as noted on the monthly average water analyses sheets are the lowest since April, 1954.

C Loop (K-27/K-29)

The "C" loop total pumpage requirement was constant at 37.5 million gallons per day, and the return water temperature of 135° F was also unchanged.

As mentioned in the previous report, there is some concern about the apparent loss of heat transfer characteristics in K-29. To improve this condition, the "C" loop water concentration ratio was lowered by increasing the make-up from 1.74 million gallons per day in October to 1.9 million gallons per day for November and December. The water control valve positions in K-502-1 closed from 55 to 49 percent open in the two months of November and December, indicating considerable improvement of heat transfer in K-29 if this building is typical. There were no power load changes in K-29 during this quarter.

In K-27, there was a total load reduction of 4 mw and the water control valve positions as indicated in K-402-3 closed from 33 to 32 percent open during this report period.

It was necessary to increase the Orocol feed rate from 185 to 267 pounds per day as a result of the increased make-up water flow.

The cost of the increased Orocol feed rate is reflected in greater water treatment costs for November and December as shown on the attached monthly average water analyses sheets.

E Loop (K-31)

There was no apparent change in the "E" loop total pumpage or in the return water temperature, despite a power load increase of 7 mw. However, this power increase was less than a 2 percent change, and there was undoubtedly some increased heat loss to ambient due to the cooler weather. The water control valve positions as indicated in K-602-3 opened from 38.5 to 42.5 percent open, but apparently, there was no over-all change as the pumpage was unchanged.

G Loop (K-33)

The changed operating conditions after adding "A" line cooled cells made it necessary to change from K-902-4 to K-902-7 for tabulating the average water control valve positions and power load as an index for evaluating heat transfer effects.

The over-all operating conditions of the "G" loop system indicate that the change in heat transfer characteristics has been negligible during this quarter; pumpage requirements remained unchanged at 220 million gallons per day with no appreciable change in power load.

Make-up Water (K-892-A and B)

	This Quarter	Last Quarter
Production, MGPD	16,697	17,874
Chemical Analysis, PPM		
Turbidity		
Raw	24.4	16.4
Finished	4.4	2.4
Calcium Hardness		
Raw	80.5	80.4
Finished	36.5	34.6
Chemical Treatment, PPM		
Lime	56.4	54.7
Ferric Sulphate	6.9	4.9

Monthly Average Water Analyses

Attached are separate water analyses sheets for October, November, and December, 1959. The zinc determination on "C" and "E" loops was discontinued after the month of October as the zinc concentration had dropped to considerably less than 1.0 ppm and could no longer be a factor in scaling or deposition. The zinc content in the "C" and "E" loops was the result of MarTreating the respective cooling towers.

M. A. Fletcher
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Approved:

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MONTHLY AVERAGE WATER ANALYSES - OCTOBER, 1959

P.P.M.	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	134	113	323	476	345	455
Metaphosphate as $NaPO_3$	0.05-	0.05-	1.46	2.15	6.05	5.83
Orthophosphate as $NaPO_3$	0.16	0.16	5.70	7.92	8.95	11.63
Total Hardness as $CaCO_3$	127	76	229	293	210	274
Calcium as $CaCO_3$	88	47	130	166	121	156
M-Alkalinity as $CaCO_3$	99	35	35	9	9	8
Turbidity as SiO_2	8.5	3.0	8.3	9.0	8.7	8.6
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Total Iron as Fe	0.09	0.08	0.08	0.08	0.07	0.08
Sulphate as SO_4	11	20	124	196	145	190
Zinc as Zn	-	-	-	0.54	0.11	-
Suspended Solids	9.3	1.1	5.8	6.6	6.3	6.7
Chromates as CrO_4	-	-	-	23.1	9.8	10.7
pH	8.0	10.1	7.7	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$0.466	$1.456	$1.558	$1.115
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	3.85	3.84	3.54

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - NOVEMBER, 1959

P.P.M.	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	135	94	350	347	323	400
Metaphosphate as $NaPO_3$	0.06	0.05	1.78	2.70	6.27	5.88
Orthophosphate as $NaPO_3$	0.05-	0.05-	5.80	6.34	10.04	12.26
Total Hardness as $CaCO_3$	113	70	230	202	188	237
Calcium as $CaCO_3$	76	36	125	106	94	118
M-Alkalinity as $CaCO_3$	79	24	32	6	7	7
Turbidity as SiO_2	17.3	3.4	6.1	4.8	5.4	6.8
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Total Iron as Fe	0.09	0.09	0.07	0.07	0.07	0.07
Sulphate as SO_4	11	35	117	163	124	173
Suspended Solids	12.0	1.8	3.9	2.9	3.5	4.5
Chromates as CrO_4	-	-	-	17.9	9.8	10.3
pH	8.0	10.0	7.7	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$0.448	$1.599	$1.578	$1.196
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	4.29	3.87	3.83

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.

MONTHLY AVERAGE WATER ANALYSES - DECEMBER, 1959

P.P.M.	Clinch River	Accelator Effluent	RECIRCULATING WATER LOOP "A" & "B"	"C"	"E"	"G"
Total Dissolved Solids	130	108	343	338	365	400
Metaphosphate as $NaPO_3$	0.05-	0.05-	1.77	2.09	7.19	5.78
Orthophosphate as $NaPO_3$	0.05-	0.05-	6.10	6.92	11.57	13.43
Total Hardness as $CaCO_3$	113	77	221	197	220	239
Calcium as $CaCO_3$	75	49	127	118	123	133
M-Alkalinity as $CaCO_3$	76	23	29	7	7	7
Turbidity as SiO_2	45.6	6.4	13.2	16.9	20.4	25.5
Copper as Cu - Soluble	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Copper as Cu - Total	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-
Total Iron as Fe	0.09-	0.07	0.07	0.07	0.08	0.07
Sulphate as SO_4	13	34	127	191	135	173
Suspended Solids	22.5	1.1	7.6	11.8	14.8	18.9
Chromates as CrO_4	-	-	-	17.9	11.1	11.3
pH	8.1	10.2	7.7	6.0	6.0	6.0
Recirculating Water Treatment Used	-	-	Calgon TG	Betz Dianodic		
Total Chemical Treatment Costs Per Million Gallons of Water Recirculated	-	-	$0.404	$1.772	$1.590	$0.935
Total Chemical Treatment Costs in Mils per MM BTU Removed	-	-	-	4.84	3.89	3.09

All water analyses are averages of those made in the Process Utilities Laboratory with the exception of the make-up water turbidities and all pH's which are averages of the operators' hourly readings.